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A Pilgrimage to Pautzeku: Chinese Bandits Capture Ordnance Officer

ARMY ORDNANCE

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The Aberdeen Chronograph—Bombs—New Musket Sights

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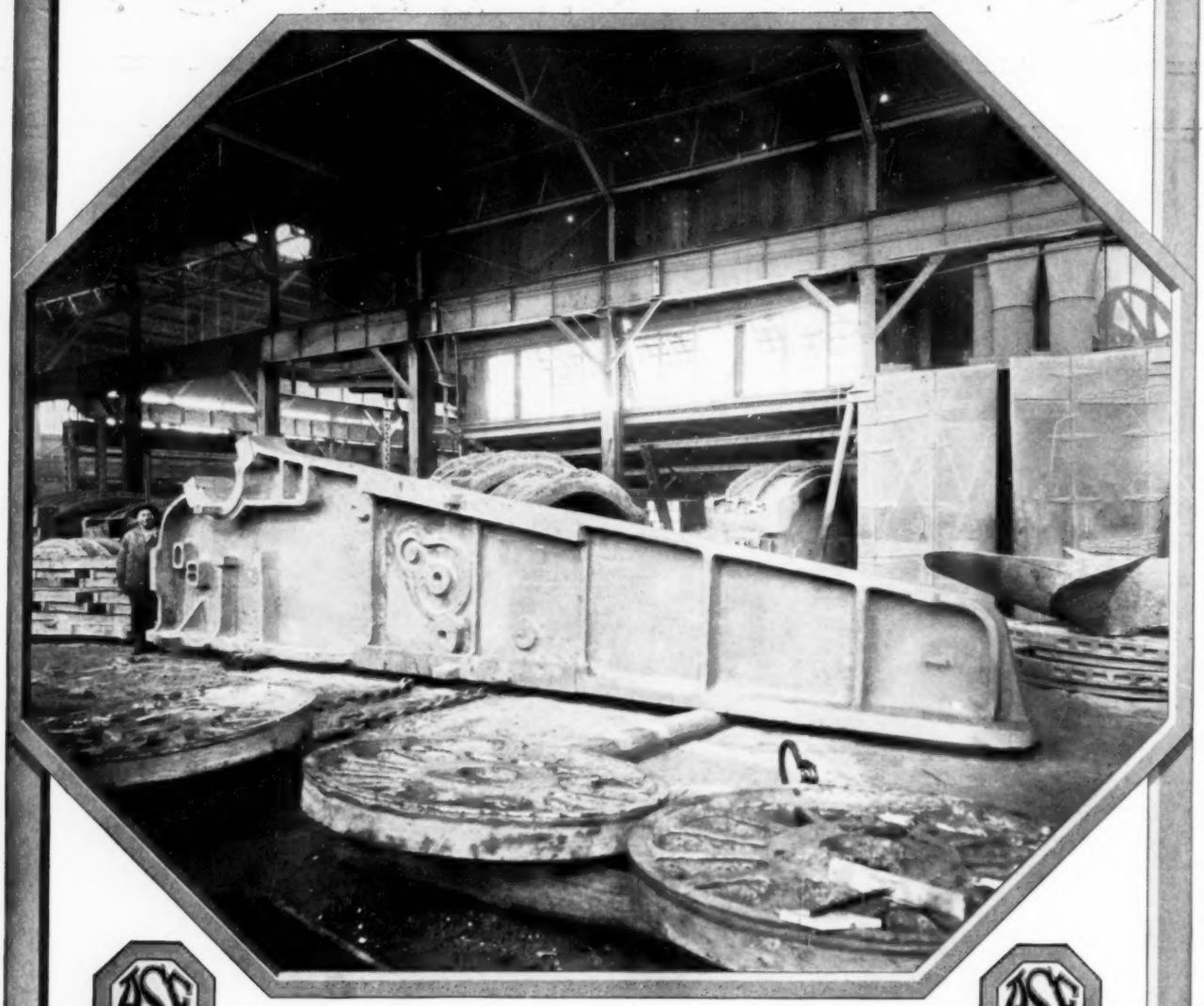

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ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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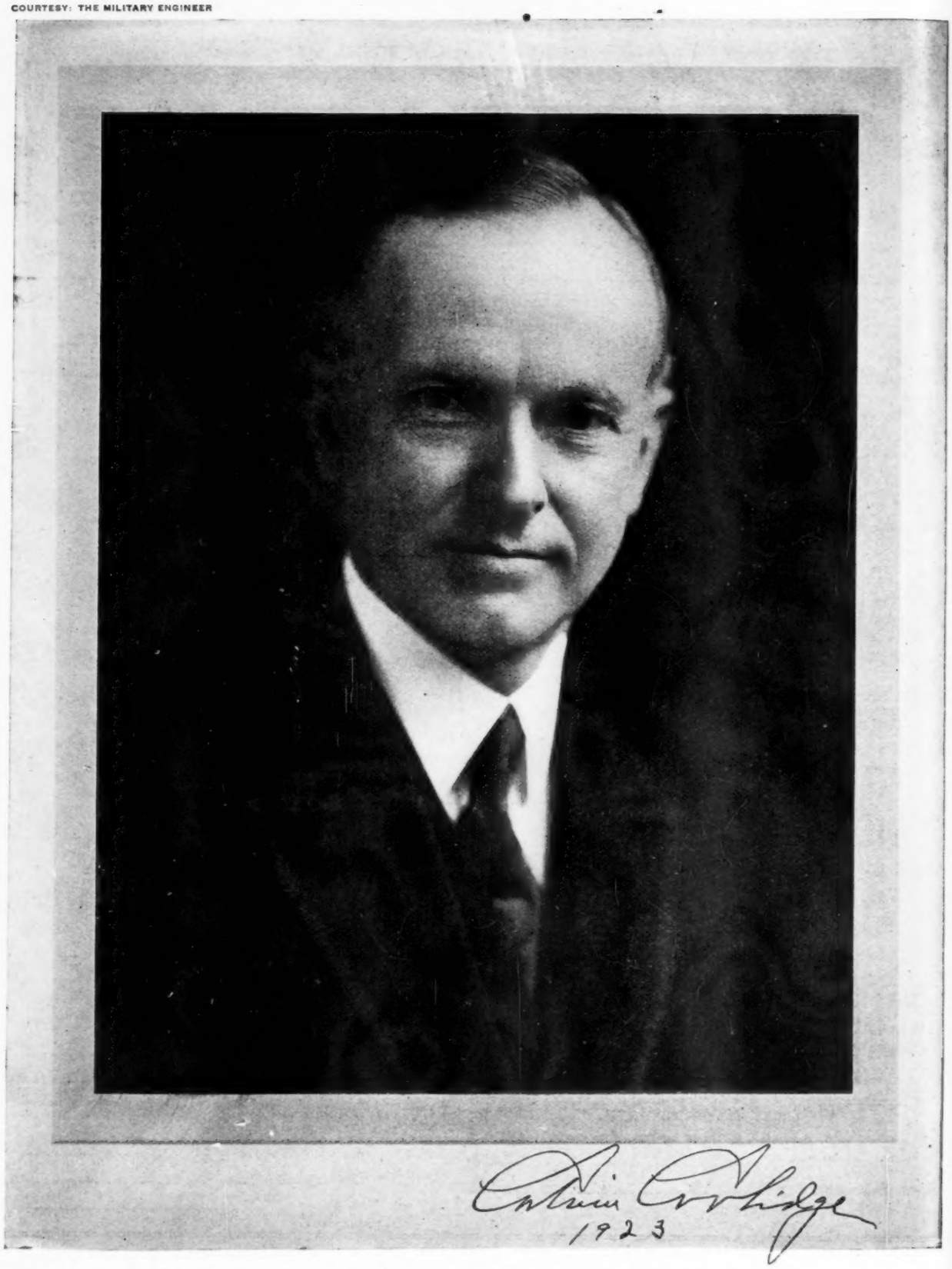

"THE Army is a guarantee of the security of our citizens at home; the Navy is a guarantee of the security of our citizens abroad. Both of these services should be strengthened rather than weakened. * * * We want no more competitive armaments. We want no more war. But we want no weakness that invites imposition. A people who neglect their national defense are putting in jeopardy their national honor."

—(*President Coolidge, in his Message to Congress, December 6, 1923*)

Editorials

Association Plans for 1924

WHILE yet on the threshold of the new year it may not be amiss for us, as members of the Army Ordnance Association, to "take stock" or, like the proverbial mariner, "take our bearings." After all, it is by a careful analysis of the work we have under way and an analysis of our success or our failure, as the case may be, that we can best understand the degree of progress that is being made. This theory applies with particular force to the Association.

The number of active members in the Association continues to augur well for its success. The year 1923 was among the most successful both with respect to new members as well as the continued support from old members. We hope for an increase in members during the coming twelve months that will not only help spread the doctrine of industrial preparedness more effectively but will also assist in achieving a better understanding of the vital principles that are involved.

1923 saw the establishment of a new local post of the Association on the Pacific Coast. The California Post has been started by a group of energetic and public-minded citizens and promises to carry on with great effect. Other posts are under way and we hope to be able to announce in the near future the formation of at least two of them.

Probably the most successful annual meeting in the history of the Association was held in October, 1923. Plans now under way, which will be announced in good time, contemplate an even greater meeting in 1924.

ARMY ORDNANCE, we hope, continues to interest all members of the Association. For the present year we plan to make it as interesting and helpful as we hope it has been in the past.

But over and above these several functions we hope for a year of vigor and accomplishment. We want every member to think ordnance and industrial preparedness and talk them whenever the opportunity presents itself. With united effort and hearty cooperation we can make the Association a vital factor in our individual and in our national life. Let's mark that down as one of our resolutions for 1924.

No more inspiring approval of our cause could be voiced than that of President Coolidge in his first annual message to Congress, December 6, 1923. "We want no more competitive armaments. We want no more war. *But we want no weakness that invites imposition. A people who neglect their national defense are putting in jeopardy their national honor.*" This pronouncement will, we believe, take its place in the history of our national defense plans.

Resolution Adopted by Directors of the American Iron and Steel Institute at their Meeting Dec. 14, 1923.

Resolved, by the Board of Directors of the American Iron and Steel Institute, that to the extent the United States Government may need the assistance of the iron and steel industry in the maintenance of conditions adequate for the military defense of this country, we pledge the active efforts of the members of this Board; and we express the belief that the entire iron and steel industry will approve the sentiment expressed and will cooperate in carrying it into practical effect.

The American Society of Mechanical Engineers

WE mean no reflection on other engineering bodies when we say that the American Society of Mechanical Engineers has realized most fully from the start the great need for adequate industrial preparedness. The cooperation of the Society with affairs of ordnance has always been a most inspiring and helpful aid. It is therefore delightfully assuring to know that this support is as active and as influential as it has always been. That this is true is evidenced by the resolutions recently adopted by the Ordnance Section of the Society. They read:

"WHEREAS, The American Society of Mechanical Engineers has adopted a policy of general cooperation with the War Department's plans for industrial preparedness, as provided by the National Defense Act as amended June 4, 1920, and

"WHEREAS, it has been indicated that the Society can render a patriotic and valuable service to the United States Government in carrying out the National Defense Act by instituting among its own members, and by urging other technical societies to participate in, the preparation and maintenance of an effective census of the technical engineering skill of the country available to the War Department in times of National Emergency as part of the plan for industrial preparedness, and

"WHEREAS, there now exists no comprehensive or accurate list of professional engineers expert in the operation of railways, coal mines, public utilities, etc., and available for immediate service in any national emergency requiring for relief such a skilled body of technicians,

"THEREFORE, be it resolved, that the members of the Society, through the Ordnance Division, offer their cooperation with the Council in taking a census of the engineering skill of the country for the use of the War Department,

"AND, that the members of the Society, through the Ordnance Division, offer their services in maintaining close contact between the Local Sections of the Society and the District Ordnance Chiefs in the carrying out of the industrial preparedness plan,

"AND, that the members of the Society, through the Ordnance Division, do everything in their power to secure the cooperation of the manufacturers and industrial groups of the nation in putting into effect the industrial preparedness plan of the United States Government."

This is a constructive piece of work which will go far to insure the success of our plans for industrial preparedness.

Who's Who In This Issue

ARMY ORDNANCE takes pleasure in introducing the following contributors in this issue:

MAJOR ROLAND W. PINGER, of the Ordnance Department, who was recently captured and held prisoner by bandits while traveling in China, has written of his experiences in an article which he prepared especially for publication in ARMY ORDNANCE. The story is as interesting as it is unique both with respect to the dangers and deprivations which Major Pinger experienced as well as to the conclusions one must draw from the deplorable conditions in that unfortunate country. While the press of the world has given much publicity to this episode, we are fortunate in being able to present the first account by Major Pinger himself which he has done in admirable fashion in "A Pilgrimage to Pautzeku."

MAJOR WILLIAM A. BORDEN, one of the foremost American authorities on bombs, begins in this issue a comprehensive discussion of his specialty. Parts II and III of the treatise will appear in the two following issues of ARMY ORDNANCE and will comprise, it is believed, an authoritative pronouncement on this new and important class of munitions. Major Borden was formerly chief of the Infantry and Aircraft Armament Division of the Ordnance Department and is now stationed at Aberdeen Proving Ground where he is carrying on extensive development work in his field.

MR. D. A. MILLAR is proof director at Aberdeen Proving Ground. He has done considerable work on interior and exterior ballistics and his duties at the Proving Ground well acquaint him with the latest development of the intricate mechanisms that are required. In "The Aberdeen Chronograph," he describes one of the newest and best of these devices. Mr. Millar gives a complete description of it which will, we believe, be of interest to many of our readers.

DR. FRED HAWKES, author of "The Malfunctioning of Ammunition," is an acknowledged authority on the loading of artillery ammunition. During the early days of the World War he was chief chemist in the great Georgetown Loading Plant near Glasgow, Scotland, where his work was commended most highly by the British Ministry of Munitions. Upon the entrance of this Country into the war and the great need for loading experts here his services were loaned by the British Ministry to assist in the design and operation of our plants, and his work at the Morgan plant was one of the outstanding accomplishments in the loading activities of those days. Dr. Hawkes is now in charge of loading development in the Ammunition Division, Office of the Chief of Ordnance.

MAJOR LEE O. WRIGHT is Chief of the Infantry and Aircraft Armament Division, Ordnance Department. Major Wright is one of the best known authorities on small arms and small arms ammunition in the Service and his story of the recent tests of "Ammunition for the National and International Matches" is both current and authentic.

"Advantages of Hydro-Pneumatic Recoil Mechanisms" is the joint work of MAJOR W. C. YOUNG and MR. D. A. GURNEY, both of the Artillery Division of the Ordnance Office. Major Young is an ordnance officer whose experience in the design and manufacture of artillery well qualify him to discuss this subject. He is now in charge of mobile carriage design. Mr. Gurney is an ordnance engineer whose many years of service in the department, in addition to his wealth of knowledge of the theory and practice of gun and carriage design likewise equip him to join in this timely discussion. Mr. Gurney is in charge of the design work in the Mobile Artillery Section of the Artillery Division.

ARMY ORDNANCE welcomes the opportunity to publish the interesting article on "New Telescopic Musket Sights," by MAJOR H. K. RUTHERFORD, who, until recently, was in charge of the development of this material at Frankford Arsenal. Major Rutherford has given considerable time and attention to the development of musket sights and his article is therefore of added interest since it carries with it the finality of one of our best informed officers on the subject. Major Rutherford is now a student officer at the Harvard School of Business Administration.

DR. J. L. SHERRICK, who presents in this issue Part I of his research data on "Fire Risks With Ammonium Nitrate," was until recently associate chemical technologist at the Pittsburgh Experiment Station of the United States Bureau of Mines. Dr. Sherrick has done a great deal of work on explosive investigations. He did some of the preliminary work on liquid oxygen explosives for the Bureau of Mines. His more recent investigations include a study of ammonium nitrate compounds, the subject of the present series of papers, and an investigation of the products of detonation of explosives.

The treatise on the "Specific Heat and Thermal Diffusivities of Certain Explosives," by MAJOR A. M. PRENTISS, is concluded with Part III which appears in this issue. Major Prentiss has presented a valuable piece of research work which, we feel, will have considerable bearing on future explosive development. Major Prentiss is on the staff of the Chief of the Chemical Warfare Service.

MAJOR COLIN E. MCRAE, author of the paper on "The Ordnance Financial Cycle," is chief of the Finance Contact Section, Office of the Chief of Ordnance. He is one of the best informed officials on matters of finance as related to the department and his work comprises one of its most important functions. It is believed that he has written an article that can be read with profit by all, especially members of the Officers Reserve Corps. Major McRae was recently commissioned in the Ordnance Officers' Reserve Corps and has written this article with that class of readers particularly in mind.

CAPTAIN JAMES L. HATCHER, who writes on "New Designs for the Next War," is Assistant Chief of the Infantry and Aircraft Armament Division of the Ordnance Office, and is in a position to write effectively on this theme. As will be seen, the article is not intended as a warning that there *will be* a next war or *when*, nor is it a propheey of the weapons with which the wars of the future will be fought. It is rather an emphatic pronouncement of the need of experimental work on small arms and in this respect its moral is well worth emphasis.

The unusual series of articles on "Transport Wagons for Medium and Heavy Artillery" is brought to a close with the installment which appears in this issue. The series is the work of MR. T. A. CONLON, an engineer in the Ordnance Department. Mr. Conlon has made a complete study of the various types of transport wagons in use here and abroad. He has given much time to the study of the German wagons in particular. His work and his explicit descriptions in this series, we believe, fill a gap of long standing in the descriptive literature on the subject.

A Pilgrimage to Pautzeku

Chinese Bandits Capture an Ordnance Officer

By

ROLAND W. PINGER

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AFTER almost two years in the tropics we were realizing our great ambition—a vacation in the Celestial Republic. So one sunny afternoon last May we crossed the Yangtse at Nanking and found waiting for us in the Pukew station, the famous "Blue Express," perhaps the finest train in the Orient. At each vestibule an immaculate Chinese car-boy smiled and bowed—we called him the Symbol of Comfort. At his side a gray-clad soldier leaned gawkily on his rifle and grinned—him we named the Symbol of Safety. Alas—before we were nine hours older Comfort and Safety had both taken to their heels, physically as well as symbolically.

Pautzeku (Carry Calf) Mountain

For at perhaps half past two Sunday morning (May 6, 1923) our beautiful Blue Express stopped with a terrific crash which I knew betokened either wreck or derailment. I jumped down from my upper berth and raised the shade. The black Shantung night was stabbed with hundreds of tiny bursts of flame, but the reports were strangely muffled—more like fire-crackers than rifle shots. Presently the firing ceased, there were excited Chinese feet and voices in the corridor, and again silence. Then pandemonium itself broke loose. Three thousand bandits swarmed over the helpless train and the night was made hideous with their uncouth yells, pistol shots and the screams of terrified women and children.

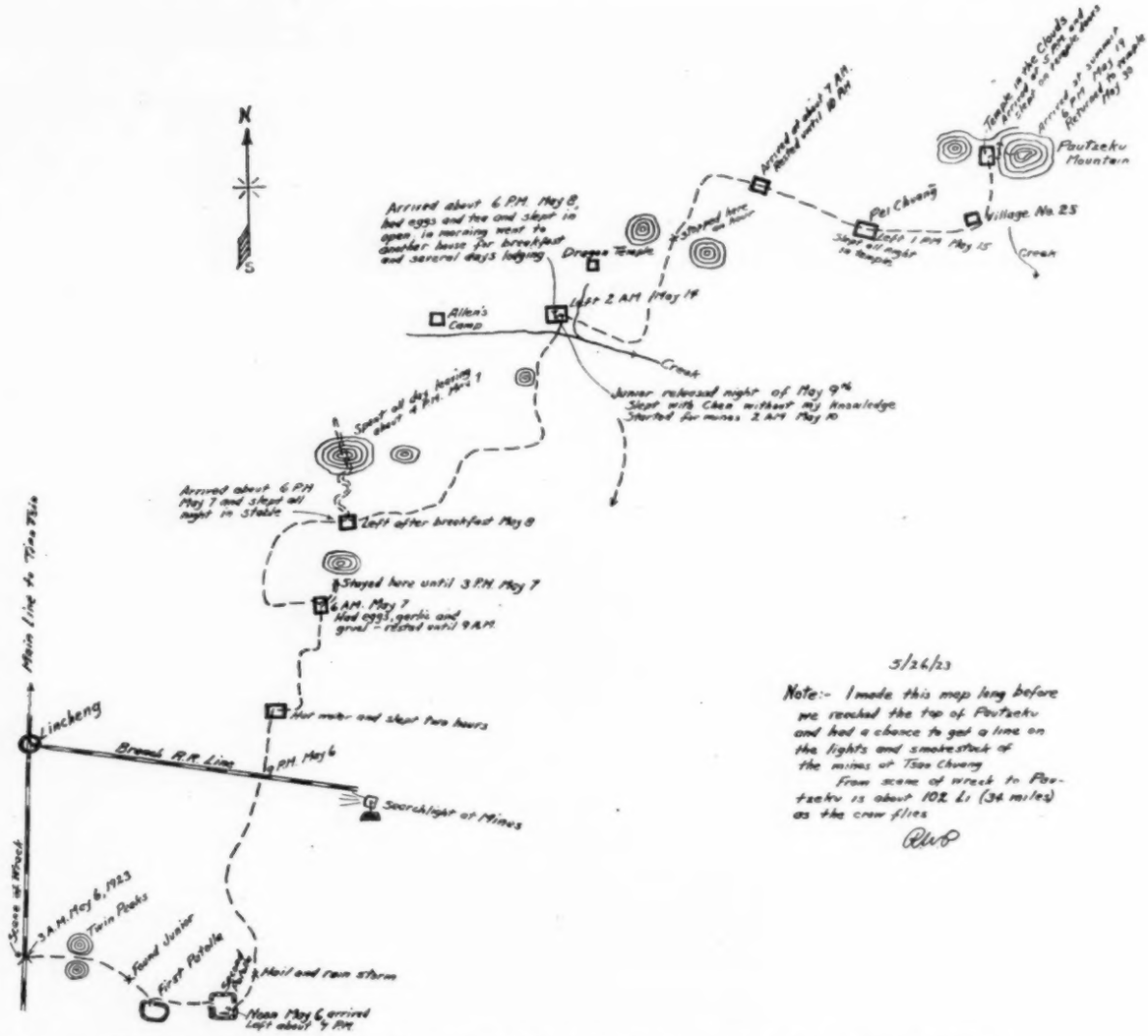
Crash went the rifle butts against the compartment doors and windows! Rather than be cut by flying glass I fumbled with our latch and just got the door open in time. A dozen screeching savages almost fell into the tiny room; by their dimly flaring candles their bared breasts glistened with the sweat of their wild dash; their queues seemed as thick as horses' tails and their faces those of demons. They shoved a dozen rifles, pistols, knives and fists into our faces and breasts and poured a perfect torrent of unintelligible Chinese words into our stunned ears. I could not imagine any object but loot, so I merely threw open my arms and said "Take everything!" They may not have understood my words but they surely followed my advice.

Major Pinger, at the Military Lines, after his release, June 12, 1923

In about fifteen minutes a second band repeated the performance but this time their object seemed different. They pounded us over the head and pulled on our ears and shouted "*Tua*" until we were almost deaf. Finally one husky pirate seized my eight-year-old son, Roland Junior, and dragged him toward the corridor. He bent the child's arm around the compartment door and fearing he meant to break it, I had to let go and they carried Junior off screaming.

My wife burst into tears and I didn't know what to do. If I followed Junior what would be the fate of her and little three-year-old Edward? If I didn't, what would become of the older boy? However, my dilemma was quickly solved for me. A third horde came through the ears and this time they meant business. Again they threatened us and mauled us, and fearing that they might kill me if I resisted further, Mrs. Pinger said, "Let's all go out together." So out we went, barefooted and in our night clothing, the little boy in his mother's arms. We found Mrs. Allen crouching in the corridor; her husband, Major Allen of the Medical Corps, and twelve-year-old son, Robert Junior, had already been dragged off by the bandits.

I had barely helped the ladies to the ground when two strong-armed villains seized me and rushed me off at high velocity. For a long time I shouted my wife's name at intervals, but her replies came back fainter and fainter. Presently I realized that for her to overtake me was futile and that the only thing possible was for me to try to catch up with the older boy who had perhaps a thirty-minute start. In the weary week which followed I had plenty of physical pain, but it was nothing compared with the anguish as to the fate of my wife and little son. Only after six days did I hear that they were alive, and it was twelve before I actually heard from Mrs. Pinger herself. They had been prodded along until, after covering perhaps six miles, they could go no further. Then the bandits, fearing for their own safety (for they were almost the last on the trail), abandoned them and in half an hour the soldiers from a nearby garrison rescued them.


N
S
Pautzeku Mountain
Village No. 25
Pei Chuang
Creek
Allen's Camp
Dragon Temple
Left 2 AM May 14
Junior released night of May 9th
Slept with Chao without my knowledge
Started for mines 2 AM May 10
Left after breakfast May 9
Stayed here until 3 P.M. May 7
Hot water and slept two hours
Lincheng
Branch R.R. Line
Searchlight of Mines
Main Line to Tien Tsin
Scene of Wreck
3 A.M. May 6, 1923
Twin Peaks
Found Junior
First Patolla
Hail and rain storm
Hsao May 6 arrived
Left about 4 P.M.
3/24/23
Note:- I made this map long before we reached the top of Pautzeku and had a chance to get a line on the lights and smokestack of the mines at Tsao Chuang
From scene of wreck to Pautzeku is about 102 Li (34 miles) as the crow flies

This Map was made by Major Pinger on Scraps of Paper, using one inch of Borrowed Pencil

Later, he pasted it together and traced it just as it was without attempting to rectify the scale. The orientation proved to be almost perfect. While it is but 34 miles from Pautzeku to the wreck, by air-line, the captives covered at least 80 miles in innumerable detours, backtracks, etc.

After a while my captors noticed my bare feet (I had been painfully aware of them for some time) and thrust a pair of broken-down European shoes on them. The shoes were hopelessly "over-size," I had no socks and my friends wouldn't give me a second to tie the broken laces, so the inevitable happened. In ten minutes I had two of the finest blisters in medical history, which later suppurating made our ten-day march through the mountains a torture to the flesh which was well-nigh unendurable. A little later I found a railway blanket on the trail and in the chilly dawn it was an excellent substitute for a bath-robe. On the nights which followed it probably saved my boy's life, for with a rock-chopped hole in the center it made a fine poncho which kept him dry, warm and fairly vermin-proof.

At dawn it appeared that I was with the rear-guard, members of which constantly dropped out of column, and stationing themselves behind convenient rocks, began firing at the soldiers who were making a much-belated pursuit. At perhaps nine o'clock those three thousand bandits on a single trail looked like the "Flight out of Egypt." And far ahead I saw what looked like a small boy perched on a Chinaman's shoulders. At the same instant the small boy's head turned and across the canyon came a glad shout "Daddy!" Presently I joined him and got him transferred to a small donkey, for the way was getting rocky and he had no shoes. He was in excellent spirits and had acquired a red silk Chinese coat, several foreign vests and two pairs of socks. At eleven we reached a fortified mountain ("patolla" they called it) where I inveigled an accommodating brigand into returning to me my wife's combination shoe-horn-and-button-hook. My first object was to convert the latter end into a dagger, but I found later that the former had a far more important though less bloodthirsty use—for ten days I was the only captive who ate his millet gruel with a *spoon;* the others

A "Temple in the Clouds"
where Major Pinger Spent a Night before going up to the Summit of Pautzeku

"Rowlett's Temple"
where he and Chen lived. Chen, a Graduate of Cambridge, acted as Interpreter for the Captives

had to use greasy chop-sticks or their fingers. I think we discovered a round dozen separate and distinct uses for this implement, so that my only advice to travelers in China is "Wear your shoes to bed and carry a shoe-horn-and-button-hook."

After an hour we left this patolla and ascended another perhaps two miles farther on. There we got a swallow or two of water, some paper-like bread and a hard-boiled egg, without which the long night march which followed would have been impossible. I was also presented with a pair of trousers. They had been tailored for a man weighing three hundred pounds; at night I could tie the ankles under the soles of my feet and the waist line still came well up into my arm-pits. No wonder my fellow-captives accused me of trying to imitate Charlie Chaplin!

Major Pinger doing "Kitchen Police"
in front of the SAP Club. Major Allen relieved him on even-number days

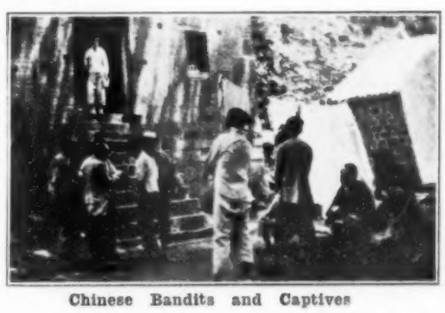
At about two o'clock the troops brought up a pair of machine guns and gave us a good drenching with lead. I tucked Junior under the best cover I could find (the bandits appropriated the best places) and wrapping the blanket around him, told him to get a little sleep. To show how a small boy's spirits can improve I must tell you what he said. "Daddy, do you think there's going to be a battle?" "I wouldn't wonder," I replied. "Well, if there is, be sure to wake me up, 'cause I want to see it," remarked my heir!

Fearing that the firing would do us more harm than good, we captives on both mountains now sent down messages to stop shooting. We didn't think the notes would help much but they did serve to gain liberty for several of our ladies, Miss Schonberg and Miss MacFadden, whom the bandits permitted to carry the messages under a white flag. But as the sun set so did our hopes. A terriffic rain, hail, thunder and lightning storm came up and under its cover and that of the darkness, we plunged down the steep northeastern slope of the mountain and made our escape. I had commandeered a small pony, much to the disgust of the Chinese lad who owned him, but while it saved my boy's shoeless feet, hanging on to the saddle cloth cost me many a rude bump on the rocks as we went down at "double-time." Had I broken my ankle I am sure they would have shot me as they would never have left a living captive on their trail at that stage.

Except for a two-hour halt in a dark little village, we traveled all night. The bandits apparently expected the troops to cut off their retreat and had an excellent system of advance and rear guards, flankers, and so on, to safeguard the column. A faint drumming in the distance meant that the "Coast was clear." We often wondered if during the first three days our captors did not have competent military direction. Later on things did not seem so well organized.

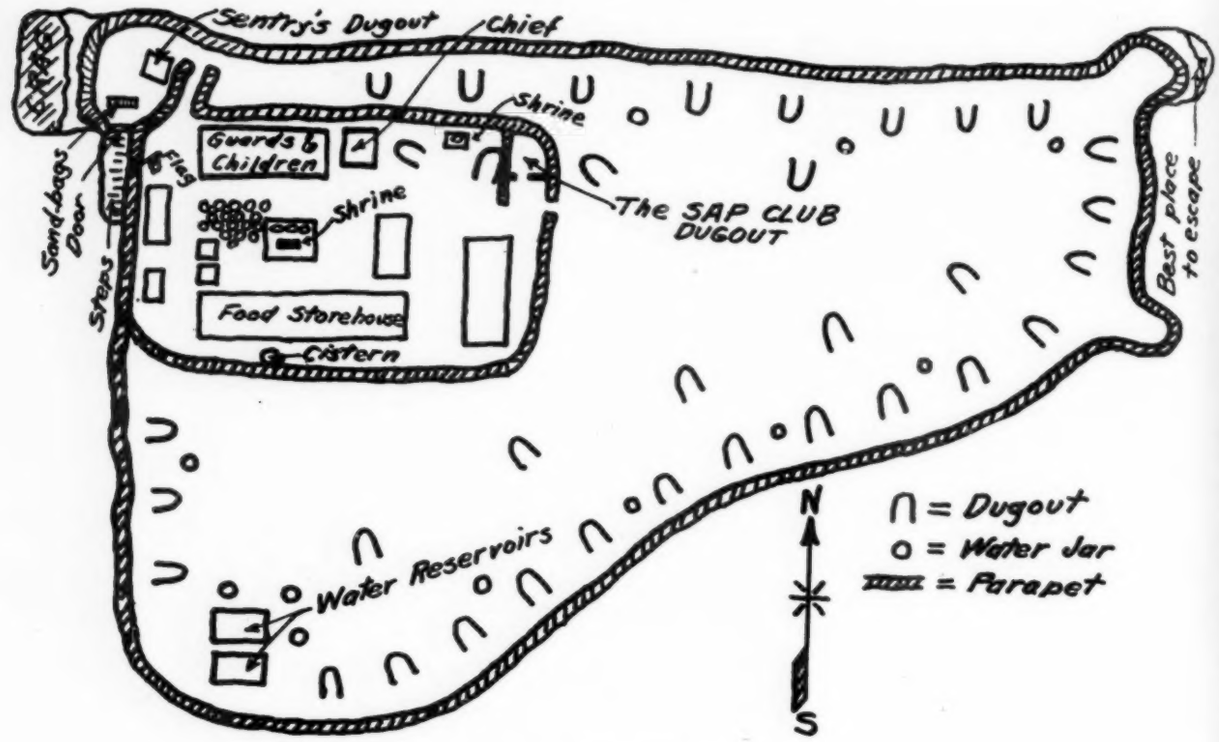
At about five in the morning I thought I could go no further and telling Junior to go on with his guard and pony I dropped out. By alternately lying prostrate on the ground until the patience of my guards became exhausted and then hobbling on a few hundred yards more, I eventually reached our first destination, a small village at the foot of a mountain.

It is impossible in an account like this to tell everything that happened in the days which followed. But a few details may be interesting. By day we usually sat on top of a convenient mountain ridge where we could observe any possible troop movements. At perhaps four in the afternoon we would come down, get some food in the villages and then march over or around the mountains to another village still further northeast. Of course we slept in the most impossible places—stables, ruined temples, the open, and so on. Food was not plentiful, for this was famine country not long ago. There was almost no rice, millet gruel taking its place. In the absence of anything better the paper-bread made from millet, gallienne, rape, beans, etc., tasted not half-bad. Salt was as scarce as caviar, for of course the tax makes it impossible for the average poor farmer to buy it. Junior was my biggest problem, so far as food was concerned; you can imagine my joy when the bandits killed a small beeve and gave me a chunk of meat with which to make ourselves some nourishing soup. Fuel was exceedingly scarce, but the bandits cheerfully shared what they had with us. After a day or two we acquired more or less permanent guards which simplified things greatly. Roland and I were fortunate enough to draw "Russky," so called because he could speak Russian fluently, having been a soldier-servant for a Russian officer as far west as Moscow. Later on Russky became the "door man" of the famous SAP Club and Mr. Solomon actually took him back to Shanghai to make an honest man of him. In parting, Russky gave me his dagger which I will always keep as a souvenir of our friendship.



Chinese Bandits and Captives

The afternoon of the fourth day found us in a typical little village (we passed through twenty-five before we



Plan of Pautzeku Summit

The summit of Pautzeku, about 500 feet long by 250 feet wide, is surrounded by almost sheer sides 250 to 300 feet high. The captives planned to escape, in emergency, by the northeast corner where it was possible to get half-way down before requiring a rope, which was to have been improvised from their bedding.

reached our destination) where the bandits made themselves thoroughly at home, shaved, cut their hair, smoked opium, drank "samsha," sang, and spat. We rested, thinking there might be another night march ahead of us. Presently there was great excitement outside and a bandit came rushing in, pointed at me and shouted "Tua!" Taking Junior by the hand, I accompanied the bandit to another corner of the village where we heard the astounding news that a message addressed to me had come in from the "outside." Finally I got possession and it read,

"The bearers of this message will conduct you to the nearest railway station. If impossible to come, send directions.

Yours truly,
Dr. E. B. STRUTHER,
Dr. INGLE."

Through an English-speaking Chinese, Mr. Chen (a graduate of Cambridge), I found that the bearer, a nice "yellow" Chinaman in contrast to our dusky friends, had been given the note by two missionary doctors and a Catholic priest at the Tsao Chuang mines, and it had taken him almost two days to find me. Mr. Rowlett, an English captive, immediately pronounced the message a "fake," but I couldn't believe it to be such. Demanding a guard and a donkey we were soon off for the next village where I believed the "Number Two Chief" was sojourning, if not the "Number One" himself.

Finding him and another returned student for interpreter (Mr. Hung, a graduate of Brown University), I explained that this, to my knowledge, was the very first word from the outside world; that here was a wonderful opportunity for the Chief to send out his terms for our release. I stated that I would reply only with his full approval, but that I should like to send out such answer *with my son*. The old man took Junior on his knee and asked me if I had any more sons. I replied that I had one aged three, whereupon he bestowed upon me the greatest of Chinese compliments — a wish that I might have two *more* sons. Then he nodded his head "Yes," and a great big load passed from my mind. Then, more or less dictated by him, I wrote my reply. He emphasized the importance of the withdrawal of the troops, saying that they had been firing on his outposts. In fact he added that if they were not ordered back to Tsinanfu within three days, he would be compelled to shoot us. However, he took some of the edge off this grim remark by having me add a postscript asking our outside friends to send us in some "foreign" food.

The Sign from the SAP Club

Punched out of a milk-can using Mrs. Pinger's famous shoe-horn-and-button-hook, which later served also as a spoon and a candlestick

as he was having trouble feeding his own men, to say nothing of us. Finding him in such good humor I at length proposed that he release "Bob" Allen also, and presently he sent up to a still more distant village for the youngster and his father. All this had taken an unbelievable amount of time, so the old man presently got tired and told me to go back with my guard and "have no further fear" for my son. Seeing I had no coat he sent out for one which Mr. Gensburger later recognized as his dinner-coat. Then I kissed my boy good-bye and rode off in the darkness with a thankful heart. Later I learned that the missionaries had given up hope and left. But the boys arrived at the mines after an all-night march and found a whole army of consuls, newspaper men, officers from the legation and so on. The next day they were safe with their mothers in Tien-Tsin, still a little sleepy but not much the worse for wear. The ladies never can understand how we could let our boys go out with a bunch of strange Chinamen, but that's because they can't possibly realize how we estimated the danger we were in, not merely from the pistols of our captors, but from the germs, lice and other vermin with which our hosts were most intimately associated.

The Moon Gate

by which one enters the "Temple in the Clouds." These three bandits were very proud of their new clothes and actually asked Major Pinger to take their pictures

Three days later we were not shot, but our Chief kept his word and "face" by the familiar method of substitution. At two one morning we were punched in the ribs and heard the awful word "Tua" again. Off we "tuaed," but by this time we had had a few good missionary meals (we shall never forget the Presbyterians at Yihsien) tucked inside of us. Also I had acquired a pair of Chinese shoes and some socks, so while the way was weary, it was not painful.

We marched for about three days and at last were rewarded by the glad shout "Pautzeku, Pautzeku!" Looking up the valley we beheld the far-famous bandit mountain rising like a volcano in the distance; we knew that we had come to the end of the trail, whatever that might mean. That night we slept in the Temple in the Clouds, a once-beautiful little monastery tucked away in a steep gorge at the base of the mountain. With the skill of veteran captives we made brick-legged beds out of the temple doors, built rude stoves and so on. A ruined altar, beautifully carved, became at once a lunch-counter and a color-line for our too-familiar hosts. Two days later our cup of joy overflowed for the line of communication with the mines became permanently established and all kinds of canned food, gold-medal cots, mail and clothing began to pour in. Never shall I be able to pay my debt to the American Chamber of Commerce of Shanghai which fed us (and for that matter the bandits, too) for the remainder of our vacation in the mountains.

A Week before their Release

Seven of the Foreign and two of the Educated Chinese Prisoners

But of course the troops had to spoil everything by again moving up (probably a tactical necessity). So one evening one of the Chiefs came up, explained the necessity for a reprisal and ordered Mr. Solomon, Major Allen and myself to the top of Pautzeku.* Up the long slope we toiled and then found a sheer wall perhaps three hundred feet in height before us. It was almost pitch dark when we had negotiated the last greasy hand and toe-hole, passed through a little bullet-riddled door at the summit, around a short communication trench and found ourselves literally "sitting on top of the world." But we decided to leave the scenery until later.

We were first ushered into a low mud and stone hut, but when we found thirty or forty Chinese prisoners already there before us (probably victims of former raids) we vehemently protested. Finding a suitable dug-out among the dozens with which the top was covered, we moved in, thus establishing what is probably one of the most exclusive gentlemen's clubs in the world, "The SAP Club!" In the eleven days of our residence we so improved the place that its original occupants could hardly have recognized it; shelves, a table, two oil-can stoves, a washstand, clothesline, and a sundial were among the conveniences installed and our captors never tired of watching us use them.

"Russky"

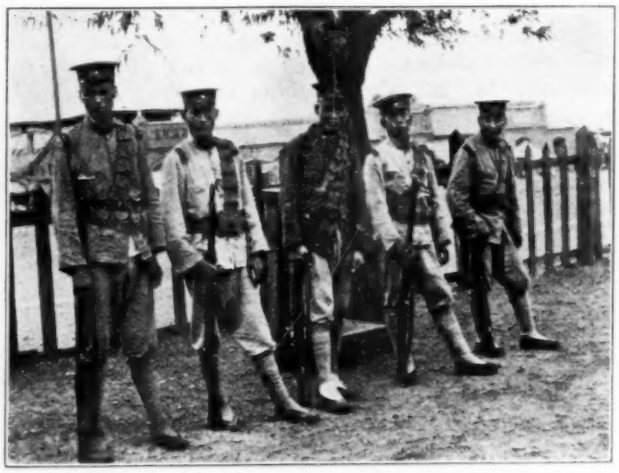
—a former soldier under Lenine, was the Private Guard of the Captives. He wouldn't let Major Pinger take his picture from the front but had no objection to a rear view

Most of the adult Chinese captives were removed the morning after our arrival, but there remained what to me was perhaps the saddest element in my entire experience—eighteen or nineteen little boy-captives from three to ten years of age. Still dressed in the tattered finery which indicated the standard of the homes from which they had been stolen, they dragged out a most miserable existence and are probably still doing so if they haven't died by this time. Water was so precious that they were never allowed to wash; from their scalps to their soles they were literally covered with filth, scabs and sores. One youngster had lost an eye and another's ribs stuck out just like a squirrel-cage. His ransom was probably hopeless (he had been there about four years) so the bandits were probably letting him starve to death. Whenever I had a touch of the "blues" all I had to do was to think of those poor little wretches and my blood would fairly boil at the stupidity and utter lack of moral sense of a so-called sovereign nation which allows such atrocity to exist.

One night as I stood on the parapet I was amazed to find the mine searchlight peering through a chink in the mountains. I quickly staked off a line with reference to

*Author's Note.—Pautzeku (Carry Calf) takes its name from the custom among the lamas when raising a small steer to pull their plow, they carry him up the mountain as a tiny calf and let him grow up.

Polaris, and in the morning transferred the angle to paper and sent it down to our friends at the mines. So it wasn't long before we had a one-sided conversation going. The bandits didn't like the looks of things, however, so on May 30th they transferred us back to the Temple in the Clouds where we could no longer serve as the "eyes of the command." On the same day, which by a strange coincidence was Allen's birthday, he and Mr. Smith, the elderly Englishman, were released. So we got out the button hook and punched a star above the "A" on the SAP CLUB sign, in memory of the first charter member to join the non-resident list. When the two lucky men had been wished "Godspeed," we lost no time in inquiring as to the reason for their release. The chiefs said "Because they are old and have white hair." That was satisfactory enough except that even Allen will admit that his whiteness is most premature. But when four young black-haired Shanghai boys were set at liberty four days later we were equally congratulatory but more mystified. "Look here," said we, to the long-legged "Number Three Chief," "One day you tell us 'that you release men with white hair,' and then you free four men with hair as black as ink. What *is* the idea?" (All through interpretation, of course). "Ah," said the Chief, "we keep to the last the ones we *like the best!*"



Chinese Soldiers Guarding the Railroad near Pekin
Their uniforms keep them from being mistaken for bandits

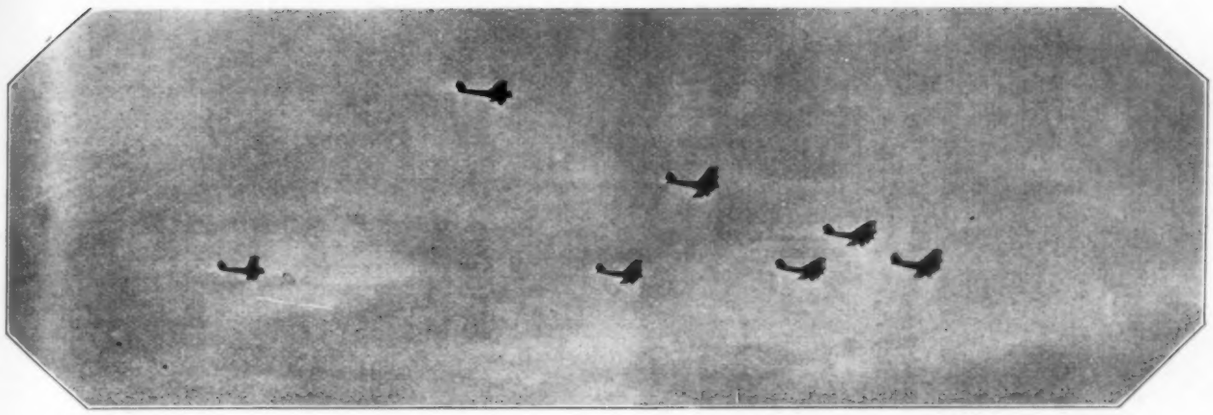
Well, we needed compliments for we now entered what was in many ways the most nerve-trying phase of the whole experience. We could be as careful as we pleased about our personal hygiene, but it wasn't possible to change China in a day. As a result the beautiful little gorge became a place of filth where flies bred by the millions. Water and fuel became scarce. Allen had secured a lot of medicine but without a doctor to prescribe we all feared disease and epidemic unless our release was effected soon. To make matters worse, the bandits themselves had difficulty in agreeing as to terms. They called themselves "The Self-governed Army for the Redemption of Something or Other," and constantly referred to the fact that except for tactical purposes, all were equal "Brothers-in-the-Hills." Opinion as to our disposition therefore varied from that of a purely commercial transaction to that of one wild fellow who insisted that we "all had crooked hearts and should be killed." Frequently I wished myself back at Pautzeku, where at least one could sit on the altar in the little shell-shocked Taoist shrine and read without one's ears being filled with the incessant jargon of the noisy and numerous Chinese.

To save my mind for future use I decided to make an "Ordnance Inspection." This was easy because while the bandits were always firing at one thing or another (despite the scarcity of ammunition), they never cleaned their rifles except as a social event. But ever so often one would produce an emery brick (I never could learn who carried it, for they were the lightest travelers I have ever seen) and each man his individual bottle of kerosene. Sitting around a jug of "Samsha" (native "hooteh") they would then take their arms apart and give them a thorough scrubbing inside and out, with the "cleaning and preserving materials" mentioned. Of course such treatment left nothing of the original tolerances; the breech mechanisms were so "shaky" that I wouldn't have fired one of their guns for fifty dollars. They seemed pleased with my interest, so I had no difficulty in using their cartridges as plug-gauges; nine times out of ten the bore at the muzzle would clear the bullet by a thirty-second of an inch all around. I frequently found three or four different cartridges in one clip; apparently bandit specifications require only that a cartridge go into the breech, and the bullet come out of the muzzle. When they found by shaking, that any of their cartridges were empty, they merely opened up a few others and "equalized" the propelling charges. If one man shot at more rabbits than another (I never saw anything hit) his friends gladly redistributed their ammunition supply so that all had about the same, about thirty rounds maximum. A French-speaking bandit who ran our camp in the last weeks, was Chief of Ordnance. He went off several times to buy ammunition from the troops who, of course, constitute practically the only source of supply. Under the circumstances the price was, of course, very high, about one dollar (Mex.) per clip. This means that each cartridge cost a coolie's daily wage.

The rifles were of all kinds; the Chinese service arms of course predominated, but there were large numbers of Japanese, German and Russian ones. In general, they resembled the arms gathered up in Mexico in 1916, except that there were almost no sporting models or those of American manufacture. At least half of the bandits had pistols, Lugers, Parabellums and Mausers. I saw a few small Colts but none of our service caliber. I considered this rather strange as I had just come from the Philippines where a steady loss of automatics has gone on for several years. I don't think I observed a single revolver and but one bayonet. Knives were frequently carried in the belt with the pistol, oil-bottle and so on. However, a favorite place was in the ankle wrapping. Water was never carried, which eliminated the necessity for canteens. If one drank it cold they fully expected to drop dead; so when thirsty very thin hot "Teha" (tea) would be prepared or procured from a nearby village.

But even with such diversion as we invented, time dragged heavily on our hands. Our newspapers had been stopped so we knew very little about the status of the negotiations. However, just as the darkest part of the night is just before dawn, so we were hardly prepared for the glad news which came up to us on the *thirty-seventh* day of our captivity. But there were the sedan-chairs each manned by two stalwart Taian coolies and if we had come in through the Moon-Gate like the "Flight Out of Egypt," we went out like "Solomon in all his glory." Five or six miles down we entered the village where the negotiations

(Continued on page 241)



Martin Bombers on Their Way to Bomb the ex-U. S. S. "Alabama." They Are Carrying 15,000 Pounds of Bombs

Bombs

PART I

By

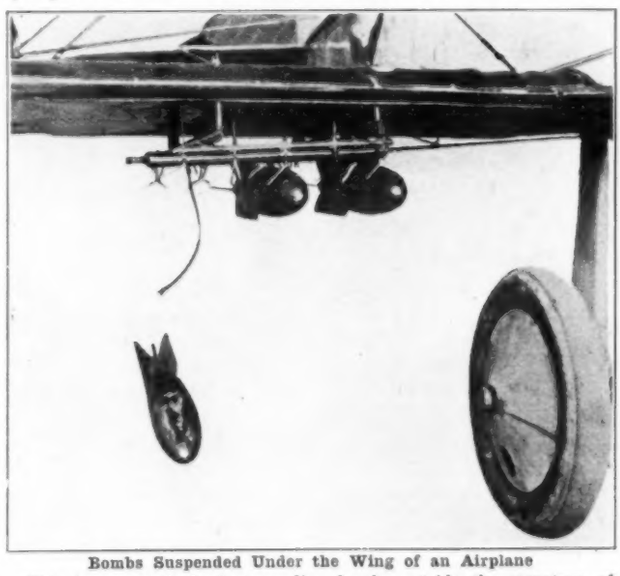
WILLIAM A. BORDEN

BOMBS are a type of munition designed to be dropped from aircraft in attacking selected targets. They are divided into high explosive, chemical, and inert classes, depending upon the type of filler used, and these classes are divided into descriptive groups typifying the effect produced or the class of target attacked. Generally speaking, a bomb consists of a metal case to which is attached three or four metal fins for guiding it in flight. The case carries the main charge of explosive or chemical. One or two fuses, with suitable detonating trains, make up the assembly and cause the bomb to function when and as desired.

The development of bombs is an outgrowth of the use of aircraft in offensive military operations. The various groups of bombs have resulted from the various types of targets which are open to bombardment from the air, and which, because of their different characteristics, require different treatment to destroy them effectively.

Almost every type of target is now vulnerable to attack from the air if suitable bombs are used. The list of targets has grown with the development of aircraft and bombs. The first bomb was probably produced with the idea of attacking troops in or close to the line of combat, and the increase in the cruising radius of the airplane developed the tactical need for bombs which could destroy storehouses and other material targets back of the combating troops. This widening of the field has progressed until troops in action, on the march, and in camp, railroads, and other lines of communication, storage areas, including ammunition and other dumps, fortifications, munition and other manufacturing plants, cantonments, cities, forests, crops, all manner of naval vessels, armored or unarmored, canals, locks, docks, airdromes and aircraft in flight are susceptible to attack by aircraft with bombs. The dropping of missiles was originally a side issue in the real effort undertaken by aircraft, but rapidly led to the employment of special air organizations with bombing as their primary function, and has continued as an important duty of all other air organizations.

The first bombs which appeared were generally converted from some other type of ammunition and probably did little damage. They, however, developed rapidly and at the close of the war very destructive missiles were available for use. The bomb represented a new idea in offensive material which has become a very important and necessary munition of war.



Bombs Suspended Under the Wing of an Airplane

This is one method of suspending bombs outside the structure of the airplane. One bomb has just been released and is shown falling. The bombs are suspended by bands. The free end of one band which released the bomb is shown. Release of the bombs is accomplished by controls which lead from the rack to the bomber's cockpit.

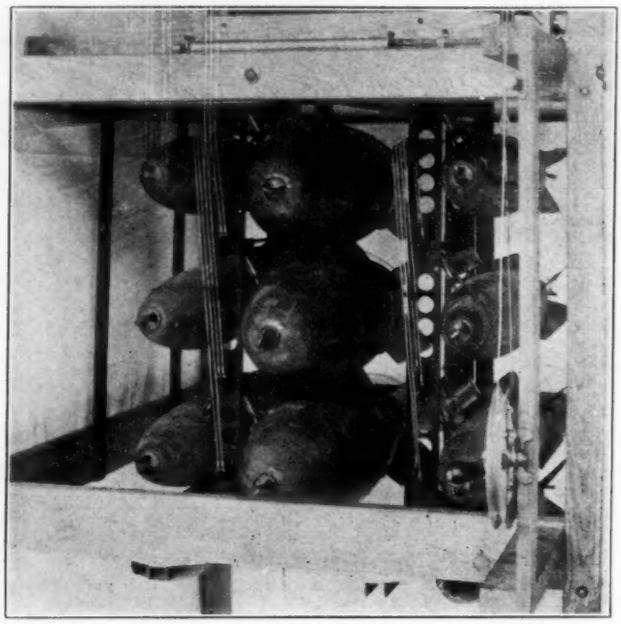
Modified hand grenades, steel darts, and converted artillery projectiles have given way to carefully designed bombs, some weighing a few ounces, others several thousand pounds as required in the development of types which would produce the greatest destructive effect on the various targets available for attack. These bombs are filled with different destructive agents,

some to produce damaging explosion or detonation, others to initiate fires, and still others to spread poison gas.

Bomb Design

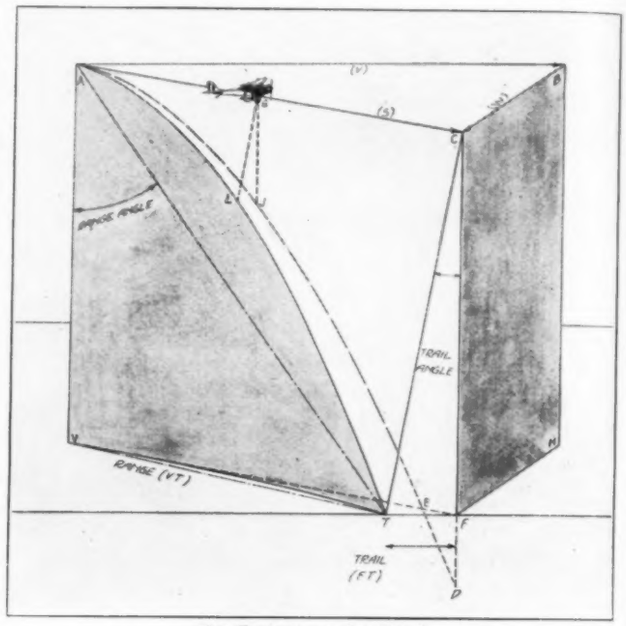
There are numerous requirements which must be considered in designing a bomb. It must, of course, produce the desired effect on the target against which it is to be used. It is apparent that a bomb which produces fragments would have little effect on a wheat field, whereas it would be very destructive when used against troops. Fireproof buildings would be little affected by bombs filled with incendiary material, but could be blown down by bombs filled with high explosive.

The number of fragments produced by the bomb which is designed for the purpose of killing troops is important, for the number of men killed or wounded depends upon the number of effective fragments produced. A certain thickness of metal in the case of the bomb, a proper ratio of weight of metal to weight of explosive, and the best kind of metal must be chosen to produce the greatest damage. Certain bombs must detonate or function the instant they strike the target, others must be delayed in action to produce the best results, and some must function in the air without hitting a target. Some have been designed to rotate in flight, but attempt is made to make nearly all fall without turning. Similar bombs should fall without great dispersion, and, if possible, all bombs should have the same trajectory or path through the air. They must be so designed that they can be carried safely on aircraft and be dropped to go off, or not go off, as desired. The latter is more of a peace time precaution than a war requirement. Its purpose is to permit the releasing of a bomb to drop "safe" if, because of engine trouble, or other reason, it becomes necessary to lighten the load carried, which may happen when the aircraft is over a locality where it would be dangerous to people or destructive to property to drop an "armed" bomb. Generally speaking, bombs should, if possible, be designed to fit bomb racks on aircraft in serv-



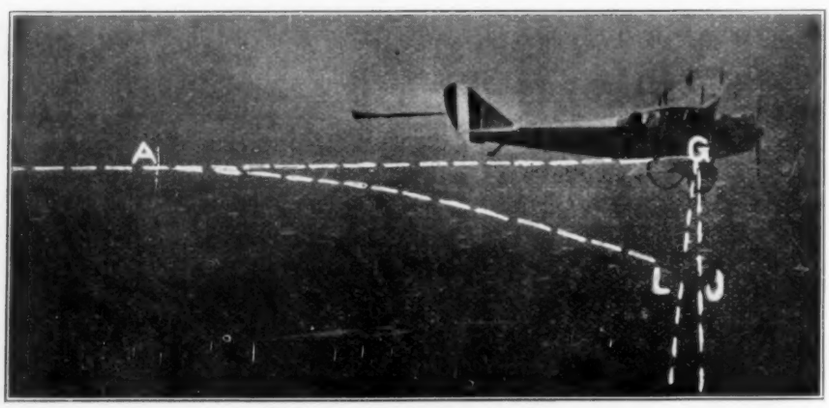
Bombs Suspended Inside the Fuselage of an Airplane

In this method of suspension the bombs are carried horizontally inside the structure of the airplane. The bombs are suspended by two lugs attached to the bomb case which fit in shackles of the bomb rack. Bombs can be dropped one at a time, or part of the load or the entire number can be dropped at once. In the illustration, those on the right and left are 100-lb. demolition bombs; those in the center are 300-lb. demolition bombs.



The Trajectory of a Bomb

The airplane is traveling with air speed V, and without wind would travel in direction AB. Wind with speed W is in the direction BC and acting on the airplane causes it to crab along the line AC with ground speed S. The bomb is released at A. It travels forward with the velocity imparted to the earth by the force of gravity. When the plane has reached G the bomb has traveled to L, having been retarded in its flight by air resistance. Had it fallen in vacuum it would have reached J directly under the airplane on a parabolic path. The bomb strikes the ground at T. Had it fallen without air resistance it would have theoretically reached D, vertically under the airplane. The effect of air resistance has caused it to trail behind by the distance TF. The vertical plane, including the bomb at any point in its trajectory and the axis of the airplane, is parallel to the plane ABHV. The diagram shows the theoretical trajectory. The actual trajectory varies from that shown due to effects of variation in the speed and direction throughout the space through which the bomb drops and dispersion attributable to variations in weight, center of gravity, contour of case, and bent fins of the bomb.



Bomb Dropping from an Airplane

View taken from an accompanying plane. Bomb released at A has traveled forward while dropping to L. It is trailing behind the vertical through the airplane by the angle JGL, being retarded by the resistance of the air.

ice, and to be stowed properly in the bomb compartment.

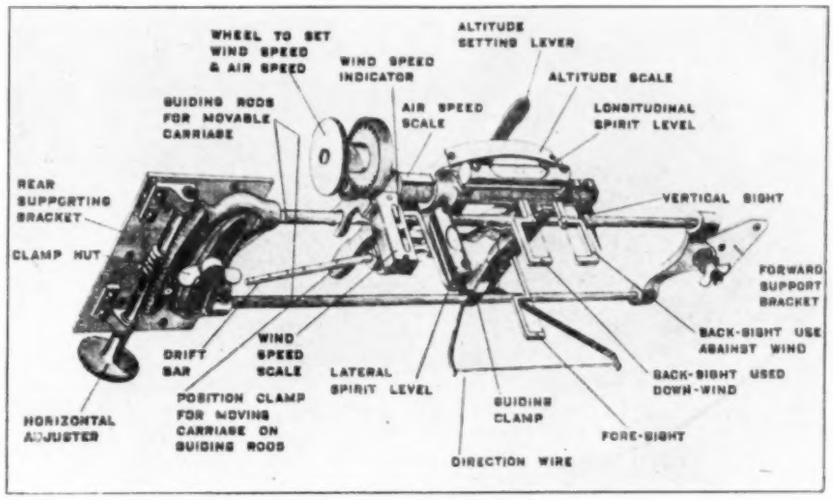
A very necessary requirement is that bombs be designed for production in quantity by facilities available in time of war. They must also be put together in such manner that they can be properly transported without injury or danger, and be readily handled and fused in the field. A casual perusal of these requirements should indicate even to the most uninformed that the designing of a bomb is not as simple a process as one would at first imagine.

Carrying Devices

Bombs are carried on aircraft by means of a suspension device termed a rack. One or two lugs, attached to the bomb case, which fit hooks or shackles of the bomb rack are used in some systems for holding the bomb. Other methods of suspension employ a sling or band, which encircles the bomb and requires no lug or eye attached to the bomb case. On release one end of the sling is dropped, allowing the bomb to fall, or the sling is dropped with the bomb and falls free from the bomb during its flight. Certain racks carry bombs suspended vertically by the nose or tail, but generally bombs are carried horizontally, so that their axis will be tangent to their trajectories when released.

In the early stages of bombing, airplanes which were available were converted for the work from machines designed purely for flying, not for military purposes. Bombs were carried on racks usually under the wings or fuselage, and being outside of the structure of the airplane, offered a decided resistance to its passage through the air. As the World War progressed, machines designed for bombing were equipped to carry bombs inside the fuselage or other structure of the airplane, and this is the present method of stowing them. Certain types of machines not used primarily for bombing have racks which suspend the bombs outside the structure of the airplanes, but it is expected that even these will eventually have provision for stowing them inside the structure. Very large bombs often have to be carried outside the airplane, as their size does not permit them to be accommodated inside the structure.

A bomb is generally released by operating a release handle or lever convenient to the bomber and connected to the rack mechanisms by suitable controls, which may be mechanical, pneumatic or electrical. The mechanism permits dropping the bombs one at a time, several at once, or the entire load, as desired. Certain mechanisms are operated by a power source which is set in motion by the bomber. These drop the bombs one after another with adjustable time intervals between each release without further effort on the part of the bomber. The time intervals are usually adjusted so that the bombs will strike sufficiently close together to make the area affected by one bomb slightly overlap the area covered by the next. This method is employed when it is desired to cut a railroad, bridge or similar target, the release of the bombs being started before the target is reached and continued until it is passed, thus insuring at least one hit.

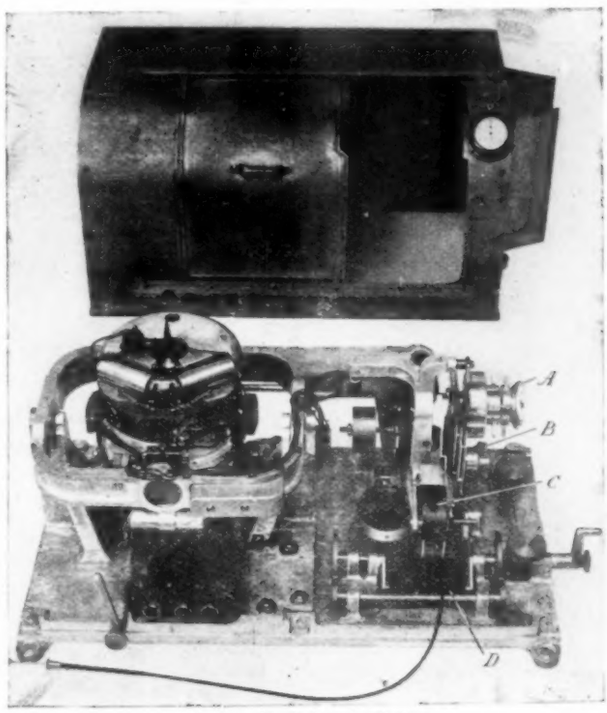


A Simple Bomb Sight

This sight is one of the first developed. It is for use in bombing up or down wind only. The altitude at which the aircraft is flying is set on the altitude scale by moving the lever which adjusts the position of the fore sight. The air speed is set on the air speed scale which adjusts the position of the back sights. Wind is then set on the wind speed scale which moves the back sights forward and back of the zero wind setting so that the front one is used if flying against the wind and the rear one if flying with or down the wind. The sight is leveled by bringing the bubbles of the spirit levels to center positions.

Bomb Ballistics

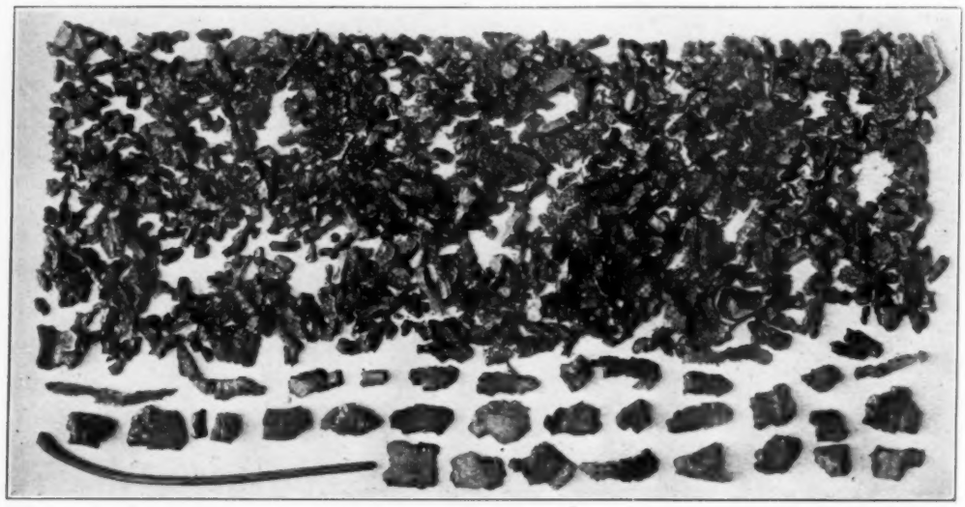
When released from an airplane a bomb has an initial forward velocity equal to the velocity of the airplane at the instant of release. Gravity acting on the bomb draws it toward the earth. The bomb is retarded in its flight by the resistance of the air through which it passes. Were there no resisting force, the bomb would remain di-



A Stabilized Bomb Sight

The gyro stabilizer on the left is attached to the sight on the right for the purpose of keeping it vertical in the aircraft. Ground speed is obtained in this sight by taking the time required by the aircraft to fly over a certain distance as measured by an angle set on the sight. This sight corrects for variation in the trajectories of different types of bombs. The timing and trajectory setting is made by the knob A. Altitude is set on knob B. These adjust a collimator C to the proper sighting angle. A glass window D permits view through the base of the sight. A cover shown above the sight, fits over it to prevent air currents from disturbing the stabilization. This sight permits bombing only up and down wind. For cross wind a very much more complicated instrument is required.

rectly under the airplane as it fell and as both it and the airplane progressed forward. Following the laws of physics, the path of the bomb in such case would be a parabola. Considering the resistance offered by the air, the path of the bomb approaches the parabola, but generally a point on the actual path lags both in distance and time behind the corresponding point on the parabola, which would have been reached had the bomb fallen without resistance. The striking velocity of a bomb increases as the height from which it is dropped is increased. However, as the velocity of a bomb increases the resistance of the air, which tends to retard its fall, increases, and at a certain velocity this resistance equals the weight of the bomb and prevents further increase in velocity. This velocity is different for different bombs. There is, therefore, an altitude above which no increase is obtained in the striking velocity of a particular bomb.



Fragments from a Fragmentation Bomb

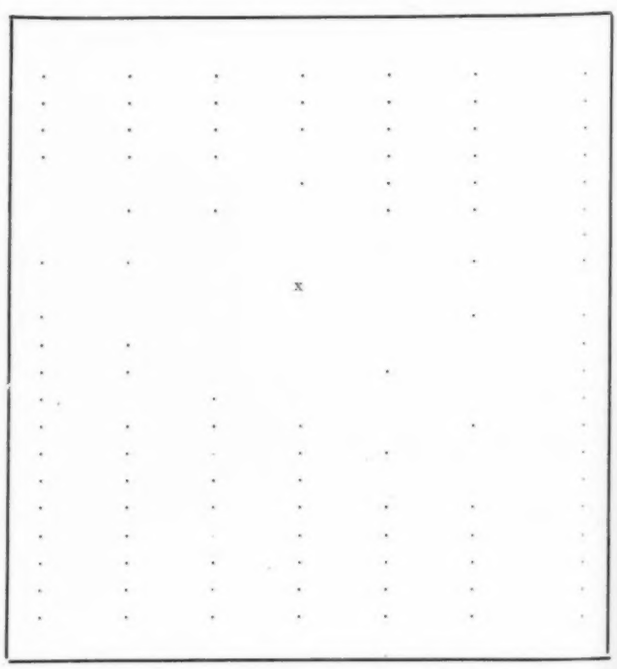
About 800 fragments are projected from the bomb case, each of which is capable of producing a casualty.

From an airplane, a bomb as it falls, appears to continue forward with the airplane, trailing, however, a slight amount behind the vertical from the airplane as it is retarded by air resistance. Theoretically, regardless of whether the airplane is flying up or down wind or across the wind, the vertical through the airplane and a line joining the airplane and bomb lie in a vertical plane which contains the axis of the airplane. Actually this does not occur, due to differences in the direction of wind throughout the space through which the bomb drops. The bomb is, therefore, displaced from a path which it is possible to compute theoretically. Irregularities in the weight, center of gravity, moments of inertia, contour of the case, and bent and distorted fins of the bomb are responsible for additional displacement. The amount of dispersion resulting from this, however, is probably within the accuracy of the bomb sight and the ability of a bomber to hit a target.

The instant at which a bomb should be released to hit a target is determined by an instrument termed a bomb sight. The means of obtaining the point of release are varied in method and principle. The simplest bomb sight

American "Heavy Case" Demolition Bombs

These are experimental types now being tested. From left to right they are, the 500 lb., the 250-lb., and the 100-lb. bombs. Their cases are of cast metal and their explosive charge, although somewhat less than that carried by the "thin case" types, is nearly 50 per cent of their weight. Their destructive effect is from a combination of blast from the main charge and fragments from the case.



Casualties from a 25-lb. Fragmentation Bomb

The bomb struck in a field 343 feet long by 312 feet wide, in which 140 men were standing in 7 rows, 20 men to a row. Thirty-four men are casualties and are indicated by gaps in the rows. X shows point of impact of bomb.

contemplates bombing with the airplane flying directly into or with the wind, for then the ground speed of the airplane is found by simply subtracting or adding the wind speed to the air speed of the airplane. Knowing the ground speed, the altitude, and the flight characteristics of the bomb, two sighting points are adjusted so that when the target is in line with them the bomb is released.

25-lb. Fragmentation Bomb

Bombing cross wind brings in complications which are difficult to handle, as the airplane's ground speed and direction are the geometric resultant of the speed and direction of the airplane in the air, and the speed and direction of the wind. The airplane points in one direction, but due to the wind effect its course with respect to the earth is at an angle to this, and from the ground it appears to "crab" obliquely across the sky. Obviously a bomb sight, which will take into account this oblique motion, must be somewhat complicated. Added to this there is the difficulty in keeping such an instrument vertical in the airplane, which, in itself, is a complicated problem, and requires rather complex gyroscopic stabilization. It would appear almost impossible to combine in one instrument a mechanism which would indicate a correct sighting angle under these conditions. Sights which produce very accurate results are now available and more accurate ones are being developed.

The American 2,000-lb. Bomb

This bomb is nearly 11 feet long and nearly 19 inches in diameter. It carries a high explosive charge weighing about 1,000 pounds. This bomb sunk the ex-German ship "Ostfriesland."

The accuracy obtained in bombing might well be questioned, yet with the present immeasurable variation in bomb trajectories, and the factors to be considered in bomb sights, not to mention the fact that bombs are dropped from an unstable platform, surprising results are obtained and bombing is becoming more accurate as new improvements in equipment are brought out. With but little actual supporting data, it is expected that the present equipment should yield 50 per cent hits on a square target with sides of dimensions variously estimated at from 2 to 4 per cent of the altitude from which the bombs are dropped. Tests will be undertaken, of course, to confirm this conclusion.

Types of Bombs

The necessity for certain types of bombs is indicated by tactical requirements developed by the Air Service. The Air Service, as previously mentioned, has found it possible to progress from attacking targets originally confined to troops in action and near the combat line to attacking munition factories and other large material targets considerable distances back of the line. As the need has developed for properly designed bombs for the attack of each new target, the Air Service has indicated its requirements to the Ordnance Department, which is charged with the development and supply of these munitions of war. The Ordnance Department through its design agencies, arsenals and proving grounds, draws up designs of bombs, tests them experimentally, and, if apparently satisfactory, produces a supply of these which are turned over to the Air Service for a service test. This test is conducted to determine whether the particular bomb supplied is satisfactory from the users' point of view, and whether it meets the tactical requirements originally indicated. If the bomb passes this test it is approved and becomes a service type. It is then manufactured and supplied in quantity by the Ordnance Department to meet the needs of the Air Service.

The World's Largest Bomb

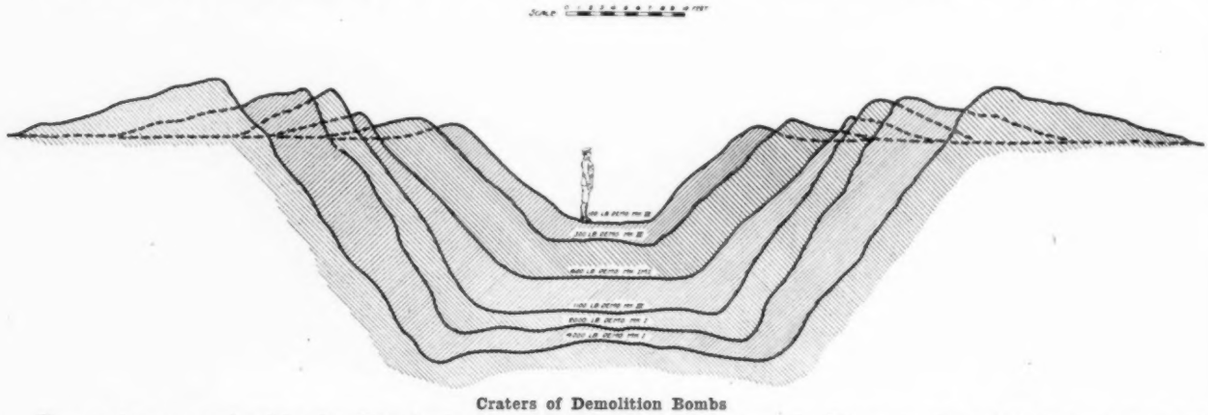
The Army 4,000-lb. bomb is 13½ feet long and 23 inches in diameter with a high explosive charge of about 2,000 pounds.

As a result very definite types of bombs have been indicated and most of these have been completely developed. In the explosive class these types have been named fragmentation, demolition, antisubmarine, armor-piercing, torpedo, aerial torpedo, antiaircraft, subcaliber, and practice. Incendiary, smoke and gas bombs make up the chemical class. In the inert class are found unloaded or dummy bombs.

Fragmentation Bombs

As their name would imply, fragmentation bombs produce destruction through fragmentation of the bomb case.

They are sometimes termed personnel bombs as they are designed for use against personnel targts, such as troops in action, on the march, in camp or in unproteeted cantonments. They are also effective against exposed personnel on the decks of ships, against airdromes, motor convoys, searchlights, field artillery units, antiaireraft batteries, and similar targets easily damaged or destroyed by fragments.



Craters of Demolition Bombs

These craters are produced by demolition bombs using delay fuzes in ordinary ground. The crater of the 4,000-lb. bomb is 57 feet in diameter and 19 feet deep (measurements taken with respect to original ground level). 1,078 cubic yards of earth are displaced by this bomb.

To produce the greatest destructive effect, it is essential that such a bomb be primarily designed to kill as many men as possible. This requires that the case fragment uniformly, and that each fragment be just large enough to carry a considerable distance and actually kill or wound a man if he is struck. There is a limit to the size of such

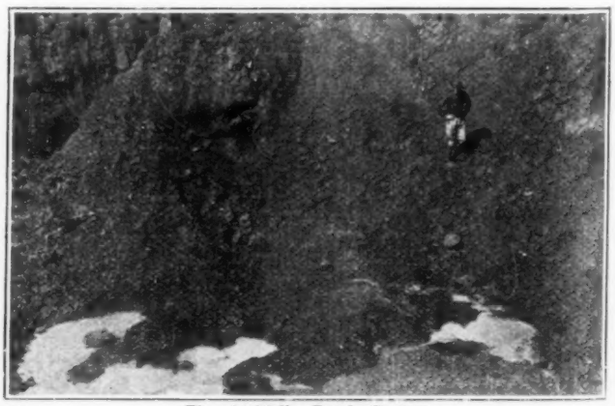
Detonation of 600-lb. Demolition Bomb

a bomb for a weight can be reached where two bombs will do more damage than a single bomb equal in weight to the two. Starting with a small bomb and progressing up, it develops that the number of men killed by a single bomb or each pound that the bomb weighs progresses to a maximum and then decreases. It has been found that the greatest number of men can be killed per unit weight by a bomb weighing about twenty-five pounds. Naturally the thickness of case, ratio of weight of case to weight of explosive, and kind of metal used affect the result. Some cases are machined to weaken certain sections to assist fragmentation. All cases are made relatively thick with low explosive contents. Forged steel, cast steel, semi-steel, malleable iron and cast iron have been used in producing different cases.

In order that the fragments be distributed as far as possible, the bomb must function before it penetrates the ground, and therefore a superquick nose fuze, which produces detonation of the main charge at or slightly above the surface of the ground, is used.

For uniform distribution of fragments the bomb should strike nearly vertically, which necessitates a low striking velocity. The use of retarding surfaces or some form of parachute has been suggested to keep striking velocity low.

It appears that a fragment of a bomb case is projected in a direction normal to the surface of the explosive at



The 4,000-lb. Bomb Crater

This view shows only a portion of the crater. Its immense size is apparent by comparison with the six-foot man standing about a third of the way up the wall of the crater.

that part of the case from which the fragment separates. The case must be so shaped that the fragments will have the greatest effective range, considering the downward striking velocity and the velocity and direction imparted to the fragments by the detonation of the bomb.

In testing the destructive effect of such a bomb, it is dropped in a field with wooden silhouettes representing men standing in rows at certain intervals. When dropped in a field about 300 feet square in which 140 silhouettes stand in seven rows, 20 silhouettes to each row, it produces

34 casualties, that is, 34 of the silhouettes are penetrated by at least one fragment. It produces about 800 effective fragments when it detonates.

Demolition Bombs

Probably the most important type of bomb for the attack of ground targets is the demolition bomb. The term demolition is applied as this bomb is designed to demolish the targets against which it is used.

Demolition Bomb Destroys and Burns Building

A test building of frame construction hit by a 600-lb. demolition bomb, demonstrating that demolition bombs are also incendiary agents.

Damage to Railroad by 112-lb. British Bomb

The 112 lb. bomb is of the "heavy case" type with only 28 pounds of explosive. In bombing railroads the maximum damage is done if a direct hit on a train is obtained.

Tactical requirements call for such bombs to attack munition plants, ammunition dumps, railroads, bridges, storage areas and a great number of other similar material targets.

Heretofore such targets had been attacked by artillery when they were within range of guns. Bombs have an advantage over projectiles fired from guns. The projectile has to withstand very heavy firing and impact stresses which require its wall to be made thick and the explosive content therefore has to be reduced. The case of a bomb has to be made only sufficiently strong to withstand impact on a target, and for those targets attacked by demolition bombs the impact forces are relatively low. This permits a bomb of this type to carry much more explosive than a projectile of the same weight. A demolition bomb carries about 50 per cent by weight of explosive whereas a projectile's capacity for explosive by weight varies approximately from 2 to 15 per cent.

When a high explosive charge is detonated a blast is produced, the destructive effects of which increase with the amount of explosive in the charge. The design of most material targets is such that they are very susceptible to destruction by blast, and therefore a demolition bomb carrying a large amount of explosive is a very effective agent against these, and for most of them is more effective than a projectile of the same weight.

There are two sub-divisions in the demolition bomb class, one called the "thin case," the other the "thick case." In the thick case a thickness of metal is used which will produce damaging fragments when the bomb detonates, supplementing the blast effect from the high explosive. This thickening of the case, however, reduces the explosive content and therefore the blast effect which can be obtained. In the thin case the metal is reduced in thickness to a minimum which permits a maximum amount of explosive to be carried, and the production of a maximum blast effect when the bomb is detonated. Such a bomb, however must have a case of sufficient strength to penetrate the type of target attacked by this class of bombs, and to accomplish this, a thickness of case is required which, in the larger bombs particularly, produces rather sizable fragments and they alone accomplish considerable destruction. In the smaller bombs the destructive radius of the blast from the detonation of the high explosive is limited by the small size of the charge, and it has prac-

Destroyer Attacked With Army Demolition Bombs

Two 300-lb. demolition bombs damage the ex-German destroyer "G-102" and start her to the bottom.

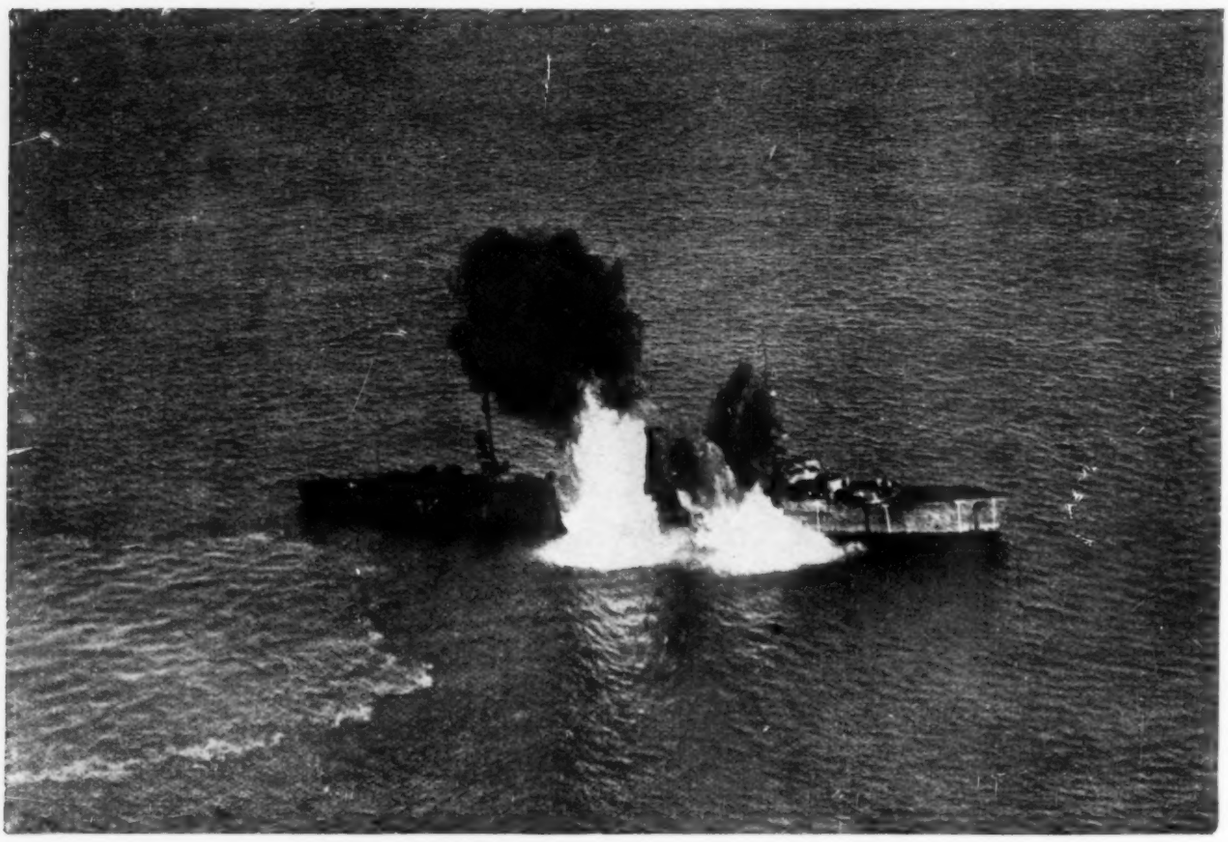
tically been demonstrated that a thickness of case should be chosen for these bombs which will allow the production of fragments, and these being projected by the force of the detonation will extend the damaging radius of the

Army 2,000-lb. Demolition Bomb Opens Hole in Bow of ex-German Battleship "Ostfriesland"

bomb beyond that reached by the blast. Fragments from bomb cases are particularly effective in damaging machinery and similar metal structures which might be only slightly affected, if at all, by blast. As a result, it may be expected that the thin case demolition bomb, as a seperate division of this class, will disappear or merge with the thick case bomb into a single class of compromise design.

The target which demolition bombs are particularly designed to attack is typified by an average factory or warehouse. This target is most effectively destroyed when a direct hit is made, although if a bomb of sufficient size is used, a hit near the building will produce very material damage. In the case of a direct hit, in order to get the full effect from the blast produced, detonation must be delayed until the bomb has passed through the roof and floors of the building and reached the ground floor or basement. The blast then literally bursts the building, blowing the roof off and demolishing the walls. When a near-hit is made the bomb must detonate on impact with the ground. If detonation is delayed the bomb will penetrate into the ground and part of the blast will be dissipated in forming the crater. The blast will also be directed upward out of the crater, and many of the fragments from the bomb case will be caught in the walls of the crater. By functioning on impact the blast and fragments are permitted to act without obstruction on the walls of the building. This difference in action results from the operation of the fuzes, of which this class of bomb generally has two, one in the nose and the other in the tail.

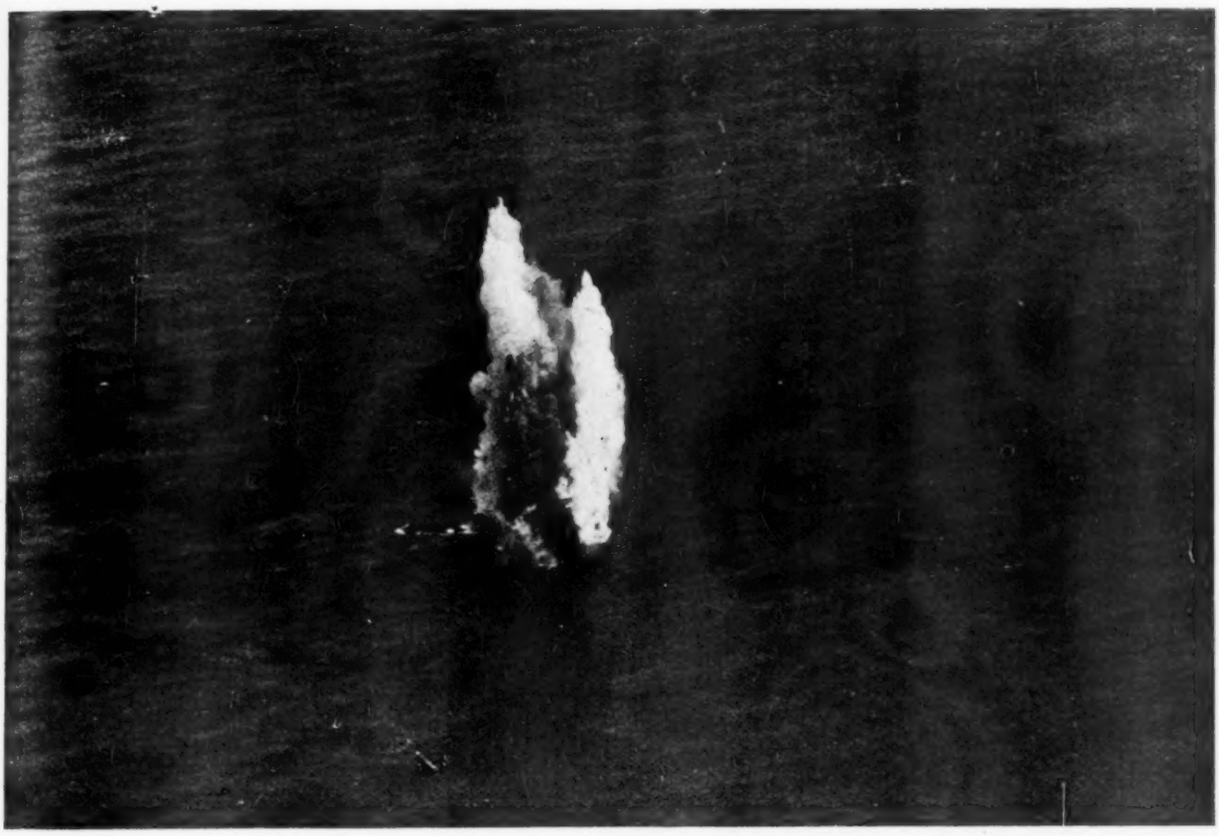
The construction of demolition bombs varies. Some are made entirely of forged steel, others of cast metal. Some are formed of sheet steel and welded, others have a cast steel nose and a formed sheet steel rear body welded to the nose. Generally, all are stream line in shape to facilitate flight and the nose is made more or less pointed to assist penetration.



Two 600-lb. Army Bombs Hitting Alongside the ex-Armored Cruis er "Frankfort"

Demolition bombs are made in different weights ranging from 100 pounds to 4,000 pounds. Originally bombs of this class were made in weights as small as 25 pounds, but results have demonstrated that little demolition effect is possible with such small sizes, and those weighing less than 100 pounds have been discarded. The only limit to

the weight of large bombs of this type is that which aircraft can carry, and yet with the modern targets available for attack, it appears that there is a limit beyond which little is gained by an increase in the size of the bomb used.



Attack With Antisubmarine Bomb on ex-German U-Boat "U-117"

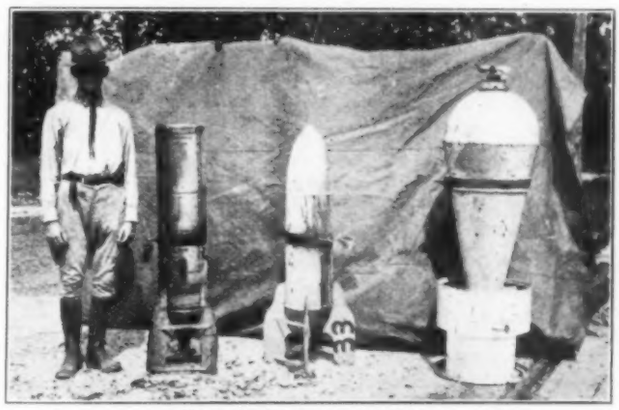
It is believed that the maximum size needed at present does not exceed the 2,000-lb. bomb.

Experiments are in progress with a 4,000-lb. bomb to determine whether one of this size is required. This bomb is probably larger than any produced by any other country. The fact that it will excavate a crater fifty-seven feet in diameter and nineteen feet deep, representing the removal of 1,078 cubic yards of earth is an indication of its power. Such a bomb might be used against the latest capital ships, against a large manufacturing plant or in bombing a large railroad terminal.

The 100-lb. bombs are too small except for targets which can be easily destroyed. They can be used very effectively against airdomes, particularly hangars. They should produce good results in attacks upon wagon or motor truck trains. Light wooden buildings are not difficult to demolish, and this size of bomb should be used with success against cantonments or even munition plants of temporary war-time construction.

As targets are increased in size and are more substantially built, larger bombs are needed to demolish them. Selection must be made from bombs ranging from the 100-lb. size to the 2,000-lb. missile, depending upon the characteristics of the target to be attacked.

Railroads and other lines of communication can be effectively damaged by demolition bombs. For such targets, delay action fuzes must be used so that the bomb will penetrate the ground before functioning and form a large crater. In bombing railroads, the maximum amount of damage is possible if a train is hit, for naturally it will be wrecked and more time will be required in clearing the right-of-way. Unless a train is wrecked, the actual damage is limited to the formation of the crater, and the destruction of the rails in the immediate vicinity, which are usually not hard to repair. The destruction of a bridge or terminal is more efficacious and against such targets demolition bombs are very effective.



Navy Antisubmarine Bombs

On the right is the 520-lb. bomb. It has a hemispherical nose and conical rear body constructed of very thin sheet steel to permit maximum explosive capacity. It is equipped with a fuze which causes the bomb to function instantaneously if a direct hit is made, and to function with delay if the target is missed. In the center is the 230-lb. bomb and on the left is the same bomb equipped with a nose bucket which insures sufficient retardation upon impact on water from low altitudes to cause the fuze to function.

Subways, sewers, water mains, gas mains, and underground electric telephone and power lines in cities can be

seriously damaged by demolition bombs equipped with delay fuzes, which hit in streets.

Aqueducts, dams, canal locks, spillways, docks, drydocks and countless other targets are susceptible to the damaging effects of this type of bomb.

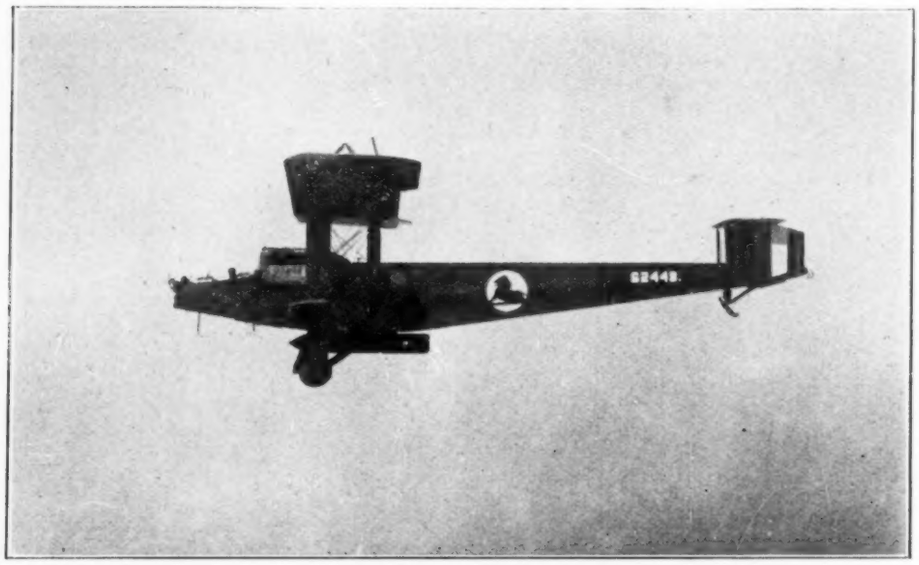
The demolition bomb, in addition to producing destruction through blast and fragmentation, also destroys through setting fire to many targets which it strikes. It is of interest to note that the various fires started in Paris as a result of bombing raids, with the exception of one small fire, were all initiated by demolition bombs. Houses which have been hit by demolition bombs in tests in this country have often been set on fire, and in at least one case a fire was initiated a hundred yards from the point of impact by a hot fragment from the bomb case.

Demolition bombs can be used effectively in attack on naval vessels. These are apparently more easily damaged by a near-hit than by a direct hit. Using a slight delay, the bomb will penetrate forty to sixty feet below the surface before functioning. The water then acts as a tamp and transmits the terrific shock of the detonation to the unprotected hull of the ship. If the hit is sufficiently close, the plates will be loosened or stove in.

The design of the demolition bomb does not permit the penetrating of armor, and therefore if a direct hit is made on an armored deck the bomb must function at once, or else it will be broken up by the impact. In functioning, if the hit is in a favorable location, it may jam a gun turret, demolish the smoke uptakes, tear up the deck causing the ship to take in water in a rough sea, or demolish unprotected superstructures. On an unprotected vessel a hit on the deck would be more serious. Bombs of the smaller sizes appear to be very effective against unprotected vessels. The largest bombs are needed to attack the first line battleship.

Antisubmarine Bombs

For the attack of submarines a special type of bomb has been developed termed the antisubmarine bomb. The bomb case is made as light as possible so as to carry the maximum amount of explosive, and has to be only sufficiently strong to stand up on impact with water, as no penetration of the hull of a submarine is contemplated or needed for destructive effect. The case may be shaped to accommodate the maximum amount of explosive without consideration being given to penetration, and as a result, a type bomb of this class has a hemispherical nose with a cone-shaped rear body all made of pressed sheet steel. In case of a direct hit such a bomb must function instantaneously. If a direct hit is not made the detonation must be delayed, and the time of this delay must be rather longer than that employed against other naval vessels to enable the bomb to penetrate deeper, and be effective against the submarine, should it be well under the surface. For the modern submarine a bomb weighing from 350 to 550 pounds is very effective, and permits a fair range of mining effect. In various tests it has been demonstrated that the army demolition bombs weighing from 300 to 600 pounds are very satisfactory for antisubmarine attack. (Part II of this article will appear in the March-April number of ARMY ORDNANCE.)



The 4,000-lb. Demolition Bomb Slung Under a Handley-Page Bomber. Note Comparative Size of Bomb and Aviator

Memorial Des Poudres Et Salpêtre

Dr. Charles E. Munroe, National Research Council, 1701 Massachusetts Avenue, Washington, D. C., desires to secure on loan copies of the last fasicules of volume 17 (1913-1914) of the above journal beginning with page 186, and the last fasicules of volume 18 (1921) beginning with page 227. Dr. Munroe is engaged in making a Table of Contents of this important publication and by drawing on several different libraries has been able to secure all of the first 19 volumes of the journal except the latter parts of volumes 17 and 18, as above indicated.

The Aberdeen Chronograph

By

D. A. MILLAR

THE Aberdeen Chronograph was developed at the Aberdeen Proving Ground during the years of 1918-1919 for the purpose of eliminating some of the errors attendant upon the firing of small-caliber guns for velocity. In its present form, it is the result of the enthusiastic initiative of Major A. L. Loomis and the ability of Dr. Paul E. Klopsteg to cope with the various physical and electrical problems involved in the development of such an instrument. Chronographs designed for the measurement of short time intervals corresponding to the flight of the projectile over a limited portion of its trajectory depend, in their operation, upon two or more electrical impulses caused by the projectile breaking the circuit. The breaking of any circuit is necessarily attended with certain irregularities and in the firing of small arms projectiles, through wire screens, these irregularities are of considerable magnitude. Some of the difficulties experienced with a "break circuit" chronograph are the probability of the wire continuing to make contact with the projectile for a variable length of time, thereby keeping the circuit intact; the stretching of the wire before breaking and the point at which the break takes place will also depend upon the relative position of the projectile and the wire at the time of impact. As a result of these possible sources of error the measured interval between screens is erroneous.

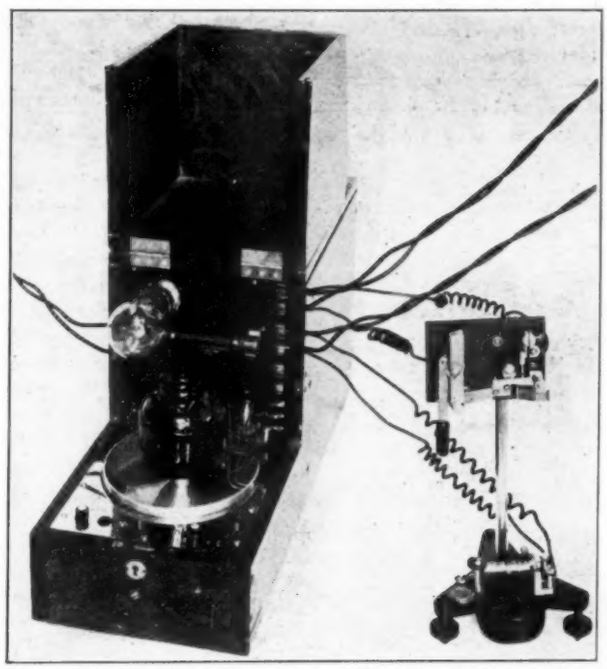


Fig. 1. The Aberdeen Chronograph (left) with Calibrating Device (right)

The Aberdeen Chronograph, unlike other short time interval instruments, depends upon the closing rather than upon the opening of circuits. The screens, therefore, are so constructed that the passage of the projectile through them forms an electrical circuit.

The Chronograph in Detail

A shallow cylindrical drum (1) (Fig. 2) of cast aluminum, mounted with its axis vertical, is driven at a constant speed by a small electric motor. The drum attains its normal speed of 25 revolutions per second in approximately 15 seconds. On its inner periphery a strip of sensitized paper equal in length to the circumference of the drum (500 mm.) is held in place by centrifugal force. Since the linear velocity of this strip is therefore determined (12,500 mm. per second), the time corresponding to any two marks made by the forming of the electrical circuit can be determined from the fundamental relationship,

$$t=\frac{D}{12,500}$$

where t is the time in seconds and D the distance between marks, measured in the direction of rotation. With t thus determined the mean velocity of the projectile at the measured interval of its trajectory would be

$$V=\frac{s}{t}$$

where V is the velocity of the projectile in feet per second and s is the distance of the measured interval or the distance between screens. Combining the two equations and eliminating t

$$V=\frac{12,500\ s}{D}$$

The motor (2) (Fig. 2) is series wound and may be operated with either 110 or 220 volts direct current. The axial bearings are of the ball type. When operating on a 110-volt circuit a resistance unit (9) (Fig. 2) of 250 ohms is connected in series with the motor. This resistance unit is changed to one of 735 ohms when using a 220-volt circuit.

Connected to the lower end of the motor shaft is the governor (4) rotating with the motor armature. By regulating the supply of current to the motor the revolving drum is maintained at an approximately constant speed. At any speed less than the required 25 r. p. s., the tungsten contact point (5) keeps the resistance (9) short circuited, and the full line voltage is impressed on the motor. When the speed exceeds the value at which it is to be maintained, the governing mass (6) moves outward, due to its centrifugal force being greater than that of the spring tension (7). Since the governing mass is rigidly fastened to the contact lever arm and pivoted at (8), the outward motion breaks the contact at the point (5), thus opening the short circuit across the resistance (9) which is in series with the motor. The speed of the motor is therefore reduced to the required value and the tungsten contact point is again closed. This cycle may be repeated many times in a second.

Theory of the Governor

The theory of the governor and its extreme sensitivity

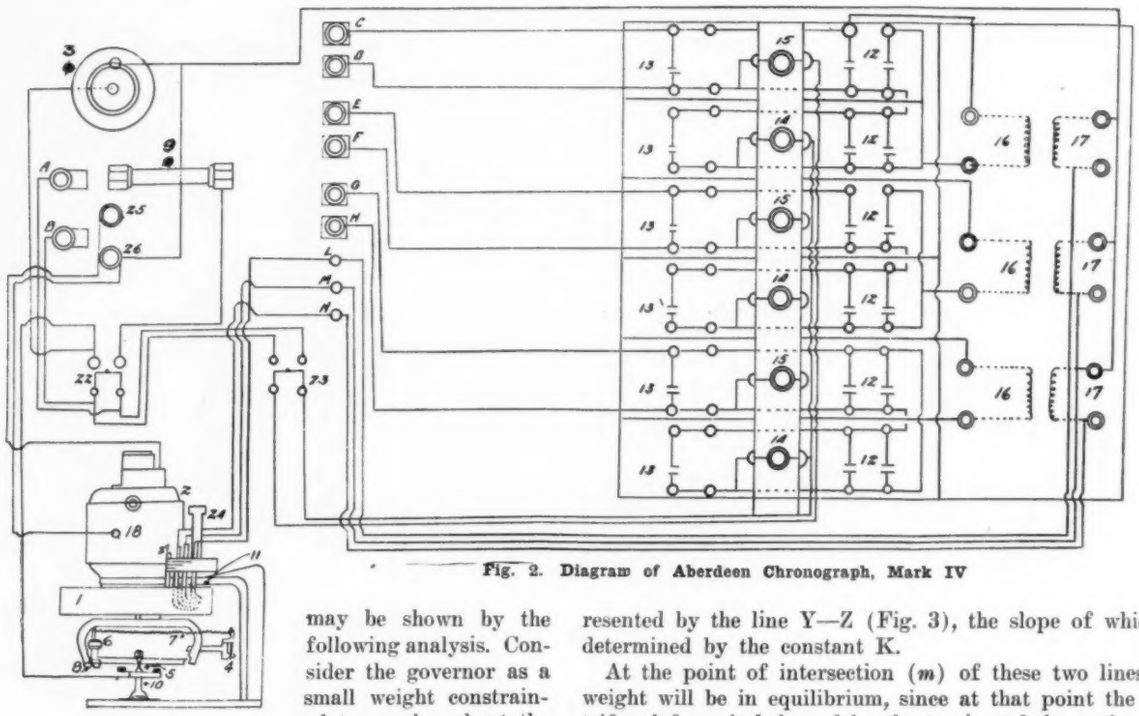


Fig. 2. Diagram of Aberdeen Chronograph, Mark IV

may be shown by the following analysis. Consider the governor as a small weight constrained to revolve about the motor shaft by a coiled spring. Then the centrifugal force exerted by the weight is:

$$F = mr\omega^2$$

Where F=centrifugal force in poundals exerted by the weight;
m=mass of the weight;
r=distance of center of mass of weight from axis in feet;
ω=angular velocity of shaft in radians per second.

The tension of the coiled spring which tends to balance the centrifugal force of the weight is expressed by the formula:

$$F' = D \times K$$

Where F′=pull of spring in poundals;
D=displacement of spring in feet;
K=a constant depending on the size and kind of wire used.

It will be seen from the equation for centrifugal force that if mv^2 is kept constant, F will increase directly as r increases. This may be represented by any straight line, as o—x (Fig. 3). Since F=o, the line starts at the origin and its slope is determined by the value of mv^2. It should be noted that the straight line o—x only represents the values of F for different values of r when mv^2 is constant.

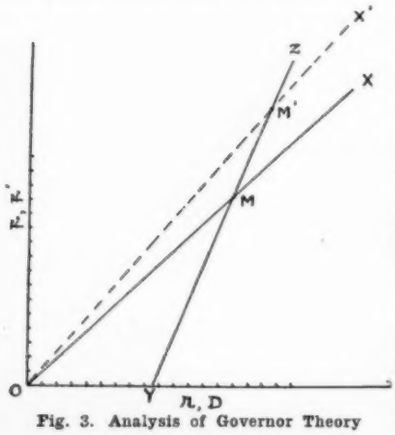


Fig. 3. Analysis of Governor Theory

In like manner it is seen from the equation for the coiled spring that F′ increases directly with D. This may be represented by the line Y—Z (Fig. 3), the slope of which is determined by the constant K.

At the point of intersection (m) of these two lines the weight will be in equilibrium, since at that point the centrifugal force is balanced by the tension of the spring and as long as the speed of the motor remains constant the weight will be maintained in that position. But if the speed of the motor increases, the slope of the line o—x will increase and the point of intersection will move to the right, making the weight move away from the axis.

The displacement of the intersection (m) for a given small change in the velocity of the motor can be increased considerably by making the slopes of the two lines o—x and y—z more nearly equal. Therefore, in designing an extremely sensitive governor the value of mv^2 and k should be kept nearly equal.

The governor shown has an adjustable spring tension rod and is rugged enough to insure excellent results for an indefinite period.

The recording system of the chronograph, which is entirely electrical, is made up of three independent units, each containing a spark point situated on the inner face of the drum. Each unit is composed of an induction coil, charging resistances and condensers.

The condenser (12) (Fig. 2) which produces the spark when the "make circuit" is used, is composed of five paraffin paper condensers, each of two microfarads capacity, and is charged through the line which supplies the motor.

For the purpose of protecting the line from excessive currents when the condenser is closed on a circuit of low resistance, the charging resistances (14 and 15) of 5,000 ohms each, are connected between the respective condenser terminals and the line.

Induction coils for each of the three units are located at (16) and (17) (Fig. 2). The discharge of the condensers through the primary (16) induces a sufficiently high voltage in the secondary (17) to produce a jump spark at the point (11) connected to one side of the secondary. The other side of the secondary is connected to the frame of the motor (18), thence the circuit continues through the motor shaft to the drum.

When the screen circuit is closed by the projectile, the very short time of contact limits the discharge of the condenser (12) to such an extent that it does not permit all

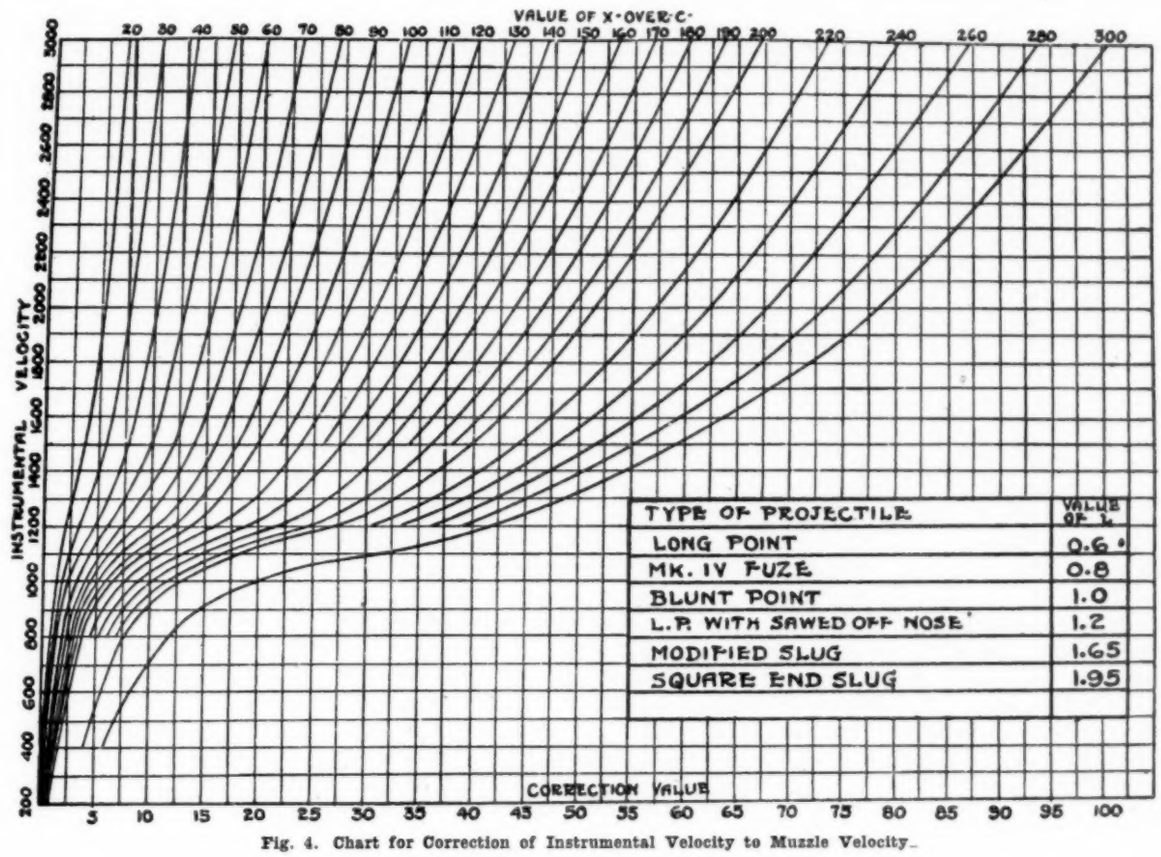


Fig. 4. Chart for Correction of Instrumental Velocity to Muzzle Velocity.

of the available energy in the condenser to become transformed into energy in the form of a spark. To improve this condition, thereby obtaining a hotter spark the auxiliary condenser (13), of about one-half the capacity of (12), is connected across the leads to the screens. Before contact occurs in the screen circuit, the potential difference across (13) is the same as across (12). Therefore these potential differences oppose each other. When contact is made at the screen, (13) discharges more rapidly than (12) because of the smaller capacity and that (12) must discharge through (16) which acts as a choke coil. As a consequence, after a very short interval of time, the potential difference of (13) has fallen considerably below that of (12). This condition sets up an oscillation in the circuit (12), (13) and (16) which persists after the screen contact has ceased and until both condensers have been restored to the same potential difference by the voltage impressed from the line. A greater amount of energy is thus transformed in the coil, resulting in a more intense spark on the sensitized record strip.

Calibration

A device for calibrating the chronograph (Fig. 1) is connected to the first and second screen circuits. The first screen circuit is closed by the action of the hammer releasing the small steel ball and that of the second by the ball bringing the lower contact point and a fine copper wire together in its flight. This apparatus is so adjusted that the time interval from the first to the second spark is exactly one-fifth of a second. Therefore, if the motor is running at normal speed (25 r. p. s.) the second spark will fall directly below the first one at the conclusion of five revolutions of the drum.

The screens used for obtaining projectile velocities on guns of 37-mm. caliber or more are made of two sheets of No. 36 gage block tin, insulated from each other by paraffined roofing paper. When firing small arms, heavy lead foil is used in the place of tin, thereby allowing an indefinite number of rounds to be fired into the same screens. A wooden clip is used to hold the screens in firing position and maintain an open circuit to the chronographs.

As stated before, the irregularities of the "break circuit" instrument are eliminated by the use of the Aberdeen Chronograph, which therefore, permits the use of shorter distances between screens without seriously affecting the accuracy of the results. In considering the accuracy of this chronograph the following sources of error may be analyzed:

Variation in time of spark jump;

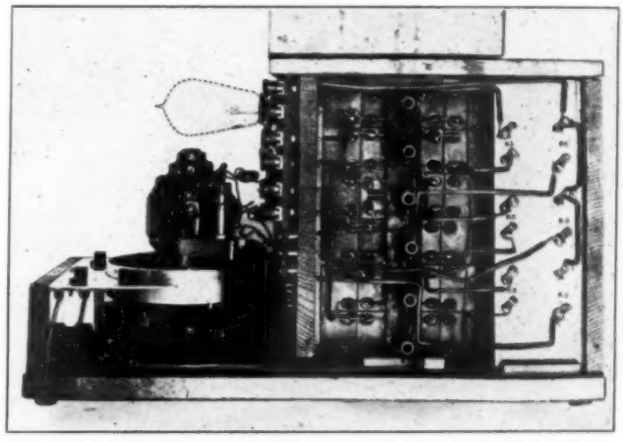


Fig. 5. The Chronograph with Side of Cabinet Removed

Determining distance between screens;
Determining distance between spark marks;
Determining speed of motor.

The time taken for a spark to jump may be computed from the formula for the time of a single complete oscillation which is,

$$t^2 = \frac{\pi}{2}LC$$

Where C = capacity in farads;
L = inductance in henrys;
t = time in seconds.

Substituting the values that are approximately those of the Aberdeen Chronograph:

$$t^2 = \frac{\pi}{2} 10^{-3}\ 10^{-5} = \frac{16}{100{,}000} \text{ of a second.}$$

Approximately one-tenth of this complete oscillation is necessary to produce a spark. Therefore, the necessary time of contact would be 16 one-millionths of a second.

For all practical purposes it can be assumed that the "spark jump" occurs at the instant the nose of the projectile touches the second sheet of tin. Convincing proof of this fact has been obtained by the perfect functioning of the chronograph in taking velocities of 2,600 f. s. on the .30 caliber service rifle. The distance between screens can be obtained, without difficulty, to within a probable error of one part in 1,000.

The speed of the motor can be kept constant to within a probable error of one part in 500. The distance between spark holes in the sensitized record strip can be measured to within one-fifth of a millimeter. With a distance of 500 mm. this would be to within a probable error of one part in 2,500. Therefore, with the sum of all these probable errors, the obtained velocity should never differ from the true velocity by more than 2.3 parts in 1,000. This probable error may be further decreased by the use of three instruments, thereby obtaining a mean of their velocities. When three instruments are used the maximum dispersion between the three readings should not exceed 3 f. s.

In computing the muzzle velocity of a projectile the formula of exterior ballistics is used.

$$S(V) = S(v) - \frac{X}{C}$$

To facilitate this operation curves showing the correction to be added to the instrumental velocity have been plotted and are shown in Fig. 4.

The correction factor is—

$$Z = i\left(\frac{d^2\ x}{w}\right) = \frac{x}{c};$$

where i is the factor dependent on the shape of the projectile, w is the weight of the projectile, d is the bore of the gun in inches, and x the distance in feet from the muzzle of the gun to the mid-point of a straight line connecting the centers of the two screens. To obtain the muzzle velocity, the chart is entered with the corrected value of Z and the correction to be applied to the instrumental velocity is taken out.

Adaptability of the Chronograph

The Aberdeen Chronograph is admirably adapted for use in the field because of its portability and that it does not require any specially built foundation. A complete field equipment, consisting of three chronographs, two 64-volt, low-capacity batteries, wire for leads, screen clips, accessories and sufficient screens for twenty rounds would make a total weight of approximately 400 pounds. As the screens can be changed very rapidly it is not difficult to fire from thirty to sixty rounds in an hour on guns of small caliber. These chronographs may be used for measuring the velocity of shell fragments and also the velocity of propagation of a detonation wave.

An Army School of Business

The Assistant Secretary of War, Colonel Dwight F. Davis, has proposed the establishment of an Army School of Business, and the project has received the approval of the Secretary of War. Colonel Davis makes the following statements concerning his proposal:

"The Supply Officers of the Army make annual expenditures of public funds mounting to many millions of dollars in times of peace and billions in time of war. It is to the public interest that these officers should have the best business education possible, in order that they may perform their important public obligations with the greatest efficiency.

"After consulting business men, educators, and specialists in business training, I have formulated a plan which has received enthusiastic support from the chiefs of the Supply Branches of the Army. This plan provides that eight officers will be sent this year to the Harvard School of Business Administration, to take the two-year course, beginning February 1, 1924. They will be selected by their respective chiefs of branches, two from the Quartermaster Corps, by Major General William H. Hart; one from the Ordnance Department, by Major General C. C. Williams; one from the Signal Corps, by Major General George O. Squier; two from the Medical Corps, by Major General Meritte W. Ireland; one from the Chemical Warfare Service, by Brigadier General Amos A. Fries; and one from the Air Service, by Major General Mason M. Patrick.

"These officer-students will be specially instructed in the teaching methods, use of material, and system of training of the Harvard School of Business Administration. The authorities of the school are co-operating heartily in the plan and will assist in the working out of a six-months' course adapted to Army needs, which will be established in an Army Business School to be formed as soon as the first graduates from the Harvard School are available as a faculty and teaching staff. Once the Army Business School is established, it will become a course in the regular training of Army supply officers.

"Such a plan should prove of great importance in promoting the business efficiency of the Army. Supply officers will not only get a good grounding in the fundamentals of business administration, but will be brought in personal touch with the business men who are at the head of their particular activities. The business methods of the Army should receive improvement through the suggestions which undoubtedly will be developed as a result of the critical study in the school course.

"The full benefit of the new school will not be attained for several years, but every business and military man whom I have consulted is enthusiastic concerning the possible benefits of the plan. They believe that it is another step toward creation of the accord of military business practice with the standards of civil business. Furthermore they believe that ambitious young men will feel encouraged to enter the military service if they know that they will receive training which will be of value to them should they later decide they do not desire to remain permanently in the Army."

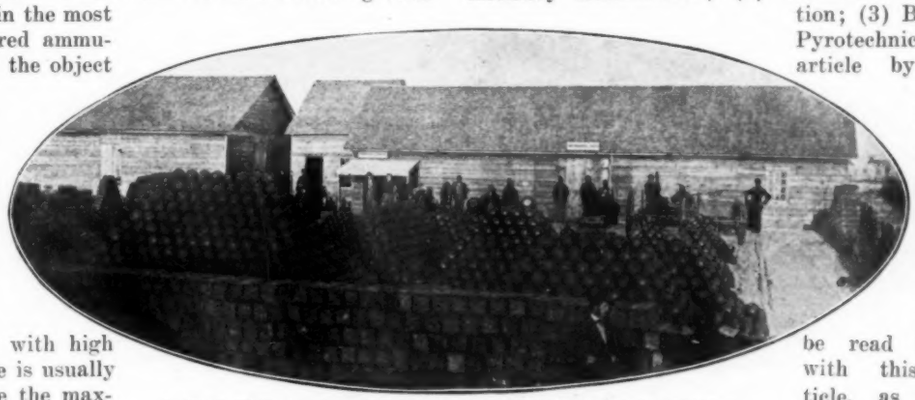
The following have been selected to take this course: Maj. Napoleon W. Riley and Capt. Edmund de T. Ellis, Q. M. C.; Maj. Harry K. Rutherford, Ord. Dept.; Majs. Edgar C. Jones and Samuel S. Creighton, Med. Dept.; 1st Lt. Lowell A. Elliott, C. W. S.; Maj. W. R. Weaver, A. S., and Capt. L. L. Clayton, S. C.

The Malfunctioning of Ammunition

By

FRED HAWKES

THE problem of the design and manufacture of present-day munitions is quite a different business from what it was in the old days of the solid cannon ball. In those days the manufacture of ammunition was comparatively simple, and prematures, "low orders" and duds were unknown. These forms of malfunctioning occur nowadays even in the most carefully prepared ammunition, and it is the object of this article to go into the question of the causes in as great detail as the limited space available will allow. A piece of ammunition whether loaded with high or low explosive is usually intended to give the maximum effect which the available energy of the explosive can produce. If through some fault of the ammunition only a fraction of this available energy is released, a "low order" results; in other words, if a shell which usually gives a certain number of fragments is fragmented to an appreciably lesser degree, a low order instead of a high order has been produced. If, on the other hand, an explosive missile through some fault of one or more of its components fails to function when fired, it is called a dud. Thus a dud is produced when a bomb does not function when dropped to "function." The failure of a bomb to function, however, when intentionally dropped "safe" does not produce a dud.



A Civil War Ammunition Depot: Morris Island, South Carolina November, 1864

Low orders and duds are bad enough but a premature is the worst form of malfunctioning of any piece of ammunition. As the name implies, a premature is produced when the ammunition explodes before it is expected to. Thus a shell may burst in the gun or near the gun, or a grenade may burst in the hands of the soldier, such prematures having more or less disastrous results.

Perfect functioning of the present-day types of ammunition can only result from the exercise of extreme care in design, the carrying out of exhaustive tests before the adoption of any design, the application of rigid inspection during production, the careful storage and transportation of the manufactured matériel, and the implicit conformity of the user to the instructions given him. The malfunctioning of ammunition is usually, but not always, the fault of the ammunition. When malfunctioning of ammunition occurs, a great amount of effort has been wasted—the effort of manufacture, the effort of transportation, and the effort of service. This, in itself, is bad enough, but a worse result is the effect on the morale of the using Services and others who learn that the ammunition intended to pave the way for an advance has not done its work effectively.

This discussion of the malfunctioning of ammunition will be dealt with under the four major headings of (1) Artillery Ammunition; (2) Trench Warfare Ammunition; (3) Bombs; and (4) Pyrotechnics. A previous article by the writer, "Ammunition Loading and Assembling," in the January - February, 1922, number of ARMY ORDNANCE, should, if available, be read in conjunction with this present article, as the two are more or less complementary.

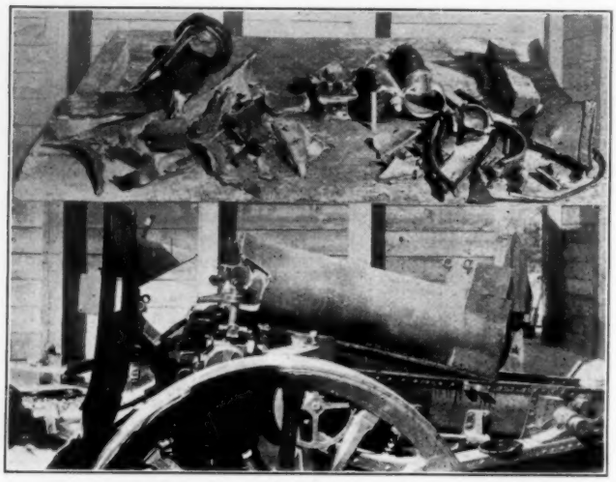
Artillery Ammunition

PREMATURES

A premature is always followed by an investigation, and, unfortunately, the investigation too often ends simply in the expression of the opinions of the investigators. When a premature occurs, the evidence is usually destroyed in the explosion. An examination of components from the same lots as those making up the ammunition which gave the premature too often ends in pure conjecture. Human frailty plays its part in the processes of manufacture of ammunition just as it does in the manufacture of any other material; and considering the large number of parts which make up a piece of modern ammunition the wonder is that prematures are so extremely rare. A defective fuze or a poorly loaded shell may, however, run the gauntlet of rigid inspection and produce a premature. By some mischance, a defect may be present to a greater extent in a certain lot of ammunition. In this case, the existence of data cards giving details of each lot of metal components, explosives and loaded parts may prove of considerable help in the investigation which follows a premature, the procedure usually being to give components and explosives from the same lots a careful laboratory examination, and also fire additional rounds in an attempt to reproduce the premature.

A premature may be produced by weakness of the shell body, defects in the explosive filling of the shell or booster, or defects in the metal components or explosive filling of the fuze. It is not impossible for the gun itself to be responsible for the premature but this phase of the question will not be dealt with here.

Weakness in the shell body may cause it to upset or increase in diameter and shorten in length under the sudden pressure of the propellant gases. The internal and external friction caused by the resulting movement of the explosive charge of the shell can well cause a premature, usually of a low order. Cracks in the base of a



Effect of High Order Premature on 155-mm. Howitzer

shell may also result in a premature due to the hot propellant gases getting at the shell explosive.

The explosive filling in the shell may be defective in such a way as to cause prematures. In point-fuze shell, cavities in the shell charge allow movement of the charge under the sudden acceleration due to the propelling force of the burning smokeless powder and such movement often produces sufficient friction to explode the charge. These cavities may be due to various causes of which cavitation is the chief. The presence of cavities in the upper portion of a charge which has been cast is a common occurrence and one which must be guarded against. Recent experiments have shown the gases in cavities in defective blocks of TNT to be principally made up of air, and cavitation in TNT would appear to be almost identical in nature to that appearing in steel castings and to be due to shrinkage plus the giving off of occluded air on solidification. The same remedy is applied in casting TNT as is used in the casting of metal, viz., the use of risers. It might be possible to eliminate much of the cavitation present in TNT castings by the addition of some material which would eliminate the occluded or dissolved gases, much in the same way as manganese is used in the manufacture of steel castings. However, TNT is perhaps cast at too low a temperature for this to be possible. Cavities in the shell charge have also been found to be due to loading into a cold shell an explosive like 80-20 amatol, plastic at certain temperatures but solid at the temperature of the air. Such cavities have been found by sectioning shell loaded during the war with hot 80-20 amatol by means of the screw-filling machine. These cavities unfortunately occur in the most dangerous region of all, in the base of the explosive charge where set-back allows the whole column of explosive to move towards the base of the shell.

Defects can also appear in TNT loaded shell after the shell has been satisfactorily loaded. Thus exudation may cause channels to form in the charge which would have the same ability to produce prematures as cavitation.

Exudation has been found to be another possible cause of prematures in TNT or amatol loaded shell as the oily exudate in issuing from the charge through the screw-threads of the adapter and booster, or the base plug where such exists, can deposit crystals of TNT which are readily detonated between the screw threads if any movement of the screw threads should take place under firing.

Prematures in shrapnel were found to be produced by cavities in the ball and matrix filling due to the balls being put in cold and the melted matrix solidifying before it had filled in all cavities. On firing, set-back caused the filling to collapse, exploding the base charge. By heating the balls and pouring in the melted matrix while the balls were still hot, prematures from this cause have been eliminated.

Base-fuzed shell above 37-mm. caliber are loaded with Explosive "D," an explosive much less sensitive than TNT. In base-fuzed shell we have the fuze in the base where movement of the charge under the force of set-back would produce more or less severe impact on the fuze with the resulting danger of a premature of a high order. Cavities in the charge and low density of the charge must therefore be guarded against.

Prematures may also be due to faulty booster loading where the booster charge is put in at too low a density thus allowing movement under the force of set-back.

The most serious prematures, however, are caused by faults in the fuze. Being usually of a high order these prematures generally wreck the gun. The metal parts of the fuze may be at fault, a firing pin may be defective and break off, piercing the primer, or a shear wire may be brittle. The loading may be faulty; small traces of the extremely sensitive mercury fulminate may have been left between the metal parts of detonator or primer; detonators may have been seated incorrectly so as to allow movement, and this, combined with too low a density of the fulminate filling, may cause a premature. The mercury fulminate must be practically free from mercury as this metal has the power of amalgamating with the detonator casing, eating holes through it so as to allow fulminate to sift through to other parts of the fuze.

High Explosive Shell which Prematured in the Bore of 4.7-inch Gun under 112 per cent Pressure

Prematures just outside the muzzle were obtained with the Mk. IV fuze when used in the 155-mm. gun. Investigation showed that these prematures were due to the retard spring which was insufficiently strong to withstand the change from acceleration in the gun to deceleration on striking the air. The incorporation of a stronger retard spring in the Mk. IV fuze (producing the Mk. IV Star Fuze) was the remedy.

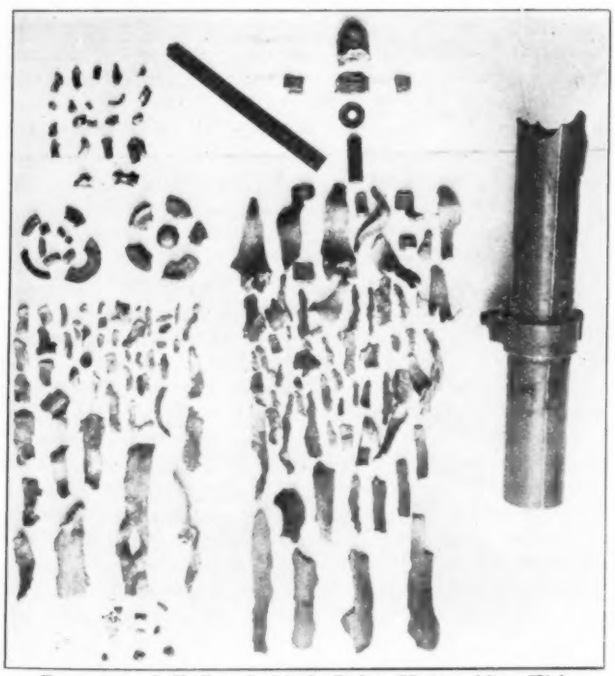
With shrapnel, time fuzes set for delay action have given prematures due to defective time rings allowing flashing through with resulting instantaneous functioning of the shrapnel.

Low Orders and Duds

In shell, low orders or duds may be caused by defects in one or more components of the ammunition, or in the method of assembly of the ammunition. They may be

caused by incorrect handling of the ammunition at the gun, and also by the terrain on which the ammunition falls. Defects in the ammunition may be in the shell or the shell charge, the booster or its charge, the fuze or its explosive contents, or they may be in the method of assembly of the components. A shell may be weak either because of faulty design or of incidental faults in the forging or casting; such a shell may break up on firing, producing a dud—if not a premature. A frequent cause of low orders and duds is the loading of the shell or booster charge at low density. In this case the setback in the gun may consolidate the shell charge towards the base of the shell, leaving an air gap between the booster and the charge if a premature is not produced. Setback may also cause the booster charge to fall away from the fuze socket, leaving an air gap between fuze socket and booster charge, and because of the inability of detonation to leap air gaps efficiently, low orders or duds may result. Careless loading of shell may result in presence of air gaps between the various components of the detonating system and the same results would be obtained as when these gaps were produced by setback. For this reason rigid inspection is insisted upon, the booster cavity in the shell being gauged before the insertion of the booster, and the explosive pellets in the booster being carefully gauged before insertion to insure tight fitting in the booster casing and fuze socket when placed in position.

Fragments Resulting from High and Low Order Detonations



Fragments of Shell and 3-inch Stokes Mortar After High Order Premature

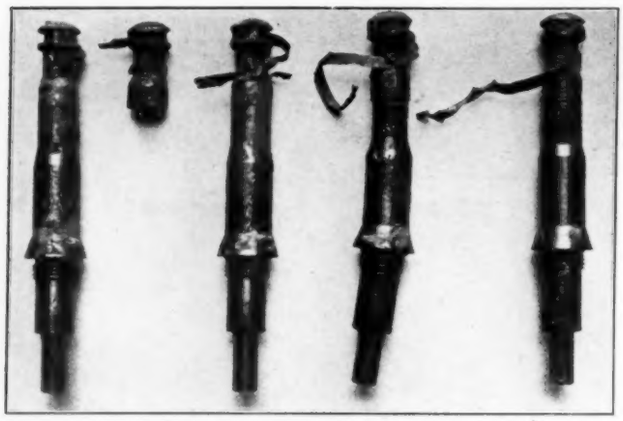
Failure of the detonating system of a shell to function properly may also be produced by densities which are too high. It is a general rule that as the density of an explosive is increased its sensitiveness decreases. In shell loaded by pressed explosives, the explosive near the booster cavity may be consolidated to a high density and the insensitiveness of this high density explosive may be sufficient to cause a low order or a dud. In the manufacture of the pellets for booster loading, care must be taken that these pellets are of a density so that they can be readily detonated, and the method of using several short pellets instead of one long one has been adopted as by this means a more homogeneous density is obtained without the extremely hard upper region which is obtained when a long column of explosive is consolidated. It may be mentioned that the pellet method of loading boosters has been shown to be superior to the method of loading in which the loose explosive is consolidated directly into the booster casing. By the latter method efficient inspection of the product is extremely difficult and extreme variations in density have been shown to exist in boosters loaded by this method and subsequently sectioned for examination.

The shell and booster charges however carefully loaded may after an elapse of time give low orders and duds due to deterioration and loss of sensitiveness of the explosives. For example, exudation from the TNT shell charge may saturate and desensitize the explosive contents of the booster, so that detonation by means of the fuze is difficult or impossible. Periodic testing of ammunition in storage is advisable so that the quality of the ammunition may be known.

Duds may be produced by fuzes which have defective metal components, or which have not been properly loaded or in which the explosive contents have deteriorated. A fuze is a comparatively intricate mechanism and depends for its efficient functioning on the movement of certain of its component parts. Defective components or careless storage leading to corrosion of parts will produce duds.

When duds are obtained, however, it is not always the fault of any component of the ammunition. Unless the fuzes are tightly screwed in the shell they will unscrew in flight and duds will result. If instructions with regard to the arming of the fuzes are not implicitly obeyed by the gun crew, duds will be produced. With the Mark III point detonating fuze for example, failure to remove the tarred tape from the safety spiral will invariably prevent functioning of the fuze, due to the inability of the safety spiral if held by this tarred tape to unwind under

the centrifugal action of the shell. Duds also may be produced due to no fault of the ammunition on those occasions when the shell falls on uneven ground in such a manner that the ogive of the shell grazes the ground, the retardation produced being insufficient to cause the fuze to function. When using a long fuze like the Mark III point detonating fuze also, the shell may fall so that a direct blow on the point of the fuze is not obtained but



Recovered Mark III Point Detonating Fuzes Fired in 155-mm. Howitzer with Inner Zone Charges

the fuze is broken off. A fuze designed to arm at a certain rotational velocity will not arm if fired from a weapon which gives a lower rotational velocity; thus a fuze intended for use in a gun will not arm when fired from a howitzer or a mortar, and a dud will result. Failures of shell to detonate on impact may also be due to more or less freak performances of the components which cannot even be guessed at, but which only recovery of the unexploded fuzed shell will explain. The accompanying illustration of Mark III fuzes, which is self-explanatory, shows the cause of previously unexplained prematures obtained when using these fuzes in shell fired with inner zone charges in the 155-mm. howitzer. The results of firings also may be deceptive in that loaded shell which would otherwise be duds due to fuze failure may give low order detonations due to the severe impact on hard ground causing the TNT or amatol charge to explode.

Propelling Charges

This article would be incomplete without a mention of the malfunctioning of propelling charges. Smokeless powder, like all other complex chemical substances, deteriorates more or less when stored for long periods of time, particularly at the elevated temperatures of the tropics. Age does not, however, take from its vigor, old powders unfortunately giving increased pressures which sometimes become dangerous. Laboratory examination of samples of smokeless powder which have given high pressures is now proceeding to ascertain if these high pressures are produced by loss of solvents alone, or whether the aging of the powder produces fissures in the grains, which, offering more surface area, accelerates combustion.

Trench Warfare Munitions

Trench Mortar Ammunition

The malfunctioning of ammunition for trench mortars is, in general, similar to that experienced with artillery ammunition, and is produced by more or less similar causes. As velocities are considerably less than in the case of artillery ammunition, prematures produced by the effects of setback are infrequent. They have, however, happened with the Mark VI fuze used in 3-inch Stokes trench mortar ammunition. Extensive firings with this fuze and examination of large numbers of the component parts of the fuze have led to the conclusion that the most possible cause of the prematures was the imperfect swaging of the needle into the striker, thus allowing the needle on setback to pierce an unusually thin web of a safety fork, penetrating the primer and functioning the fuze. By the use in practice firings with the Stokes mortar of practice ammunition in which a black powder booster and an inert filling for the shell are used, danger has been reduced to a minimum.

Low orders and duds are frequent with the present stocks of war-time high explosive loaded ammunition for this trench mortar, due principally to deterioration of the hygroscopic explosive charge.

Grenades

The present types of grenades were developed during the World War. They are of the simplest possible design, the firing mechanisms being such that their manufacture does not encroach on the facilities available for the production of artillery fuzes. The explosive used in the loading of hand grenades during 1918, and the firing mechanisms (bouchon and detonator assemblies with their springs under tension, were not intended to be stored years before being used. Hence in no other type of munitions of war, excepting perhaps pyrotechnics, has there been so much deterioration. Fortunately this deterioration shows itself in the production of duds and low orders rather than prematures. During the first days of production of grenades, prematures were of frequent occurrence, being due generally in hand grenades to the primer shooting past the delay column and exploding the grenade instantaneously. Such prematures now are practically unknown. The explosive charge of grenades has, however, deteriorated to such an extent, producing such a large number of duds, that it has been decided to salvage practically all war-time loaded grenades and load the grenades in the future with crystalline TNT. The use of the latter explosive does not produce what is considered to be the best fragmentation, the grenade body being broken into an extremely large number of small fragments, and so the development of a more suitable explosive, slower in action than TNT but with better keeping qualities than the old explosive, has been undertaken. For practice purposes, empty grenades are being used, the detonator of the firing mechanism being capable of fragmenting the grenade body sufficiently to make the point of burst visible, the elimination of the high-explosive charge minimizing the danger which might result from premature. A development has, however, been under way for some time to obtain an inert filling for the grenade with perhaps a modification of the explosive elements of the firing mechanism to obtain a grenade which will give the soldier exactly the same practice in assembling the complete grenade as with the real article, and also to make the point of burst more visible, with the additional advantage of reducing still further the dangers produced by prematures.

Present stocks of firing mechanisms give an excessive proportion of duds. Some manufacturers used a rust-preventing oil which has since hardened, clogging the spring to such an extent as to make it unable to bring over the striker with sufficient force to function the primer;

(Continued on page 264)

Ammunition for the National and International Matches

By

LEE O. WRIGHT

Test of National Match Ammunition

ON November 5, 1923, a special Board, appointed by the War Department for the Testing of Arms and Ammunition for the National and International Matches, 1924, met at Aberdeen Proving Ground, Aberdeen, Md., and tested the ammunition submitted by Frankford Arsenal for the National Matches.

While this was the first test of this kind ever held at Aberdeen Proving Ground, the personnel there acquitted themselves in a very creditable manner. No other test has ever been run so expeditiously and so smoothly.

As the commercial loading companies were not invited to enter this test, Frankford Arsenal was the only entrant. Three samples of caliber .30 ammunition were submitted for test as follows:

Lot No. 1—

Bullet, Type "A," F. A. Drawing A-23175, rev. 10/30/23.
Powder Charge, 47.0 grains of HiVel, Lot No. 1484.
Instrumental Velocity at 78 ft., 2701 f. s.
Mean Pressure, 49,000 lbs.

Lot No. 2—

Bullet, Type "A," F. A. Drawing A-23175, rev. 10/30/23.
Powder Charge, 51.5 grains of du Pont No. 1145.
Instrumental Velocity, 2697 f. s.
Mean Pressure, 48,740 lbs.

Lot No. 3—

This is a sample of the regular production of 1923 National Match ammunition, taken from Lot No. 804, which our records show gave the best accuracy in the acceptance tests of all lots of this ammunition.

Practically the only difference between Lot No. 3 and Lot No. 1 was in the shape of the bullet. Type "A" bullet had the 9° boat-tail, while Lot No. 3 was loaded with the National Match bullet, 1923, which had a boat-tail of 6°.

Thirty targets of ten shots each were fired at 1,000 yards, and fifteen targets of ten shots each at 600 yards, using a standard Mann barrel and "V" block. The following results were obtained:

LOT NO. 1—WINNER

1,000 YARDS

Group Diameter	*Extreme Vertical*	*Extreme Horizontal*	*Mean Radius*
18.112	17.315	10.433	5.685

600 YARDS

Group Diameter	*Extreme Vertical*	*Extreme Horizontal*	*Mean Radius*
7.438	6.495	5.851	2.26
Figure of Merit--- 4.543			

LOT NO. 2

1,000 YARDS

19.970	19.457	9.678	5.706

600 YARDS

8.893	7.782	6.326	2.676
Figure of Merit--- 4.696			

LOT NO. 3

1,000 YARDS

20.399	19.046	11.07	5.700

600 YARDS

7.932	6.378	6.72	2.466
Figure of Merit-- 4.622			

The figure of merit was determined by taking the mean of the mean radii of all targets fired with each type of ammunition.

Three lots of caliber .45 pistol ammunition were also submitted for test:

Lot No. 1—

Bullet, Frankford Arsenal 230-grain flat hollow-base bullet with diameter of .4515 inch.
Powder Charge, 5.2 grains of Hercules Special Bull's-Eye, Powder Lot No. 30-D.
Instrumental Velocity, 795 f. s.
Mean Pressure, 13,122 lbs.

Lot No. 2—

Bullet, Frankford Arsenal 230-grain flat hollow-base bullet with diameter of .4515 inch.
Powder Charge, 5.7 grains of du Pont Pistol Powder No. 5.
Instrumental Velocity, 798 f.s.
Mean Pressure, 13,095 lbs.

Lot No. 3—

This is a sample of the regular production of Frankford Arsenal 1923 National Match pistol ammunition, selected from Lot No. 286-1.

This ammunition was tested at 50 yards, using a combination caliber .45 pistol barrel in the receiver of the Model of 1903 rifle, held in the Frankford Arsenal machine rest. The results obtained were as follows:

LOT NO. 2—WINNER

Group Diameter	*Extreme Vertical*	*Extreme Horizontal*	*Figure of Merit*
3.788	3.184	2.776	2.983

LOT NO. 1

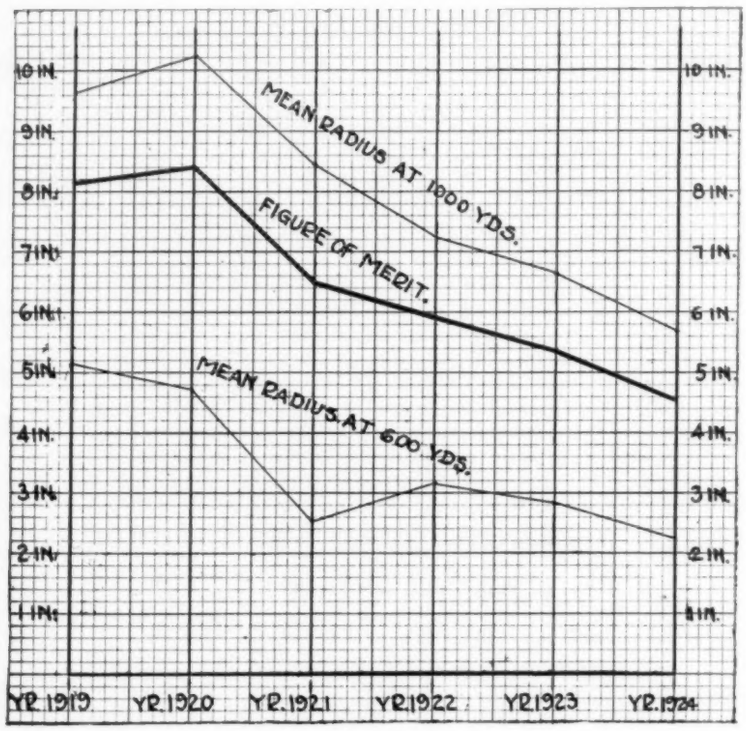
4.124	3.46	3.025	3.246

LOT NO. 3

4.863	4.005	4.139	4.074

The figure of merit for this ammunition was obtained by taking the average of the means for the extreme vertical and extreme horizontal for each target.

It is interesting to compare the results obtained with this test with the results obtained in 1921, 1922, and 1923, which were conducted under similar conditions:



Comparative Accuracy of Cal. .30 National Match Ammunition from 1919 to 1924

1921—FRANKFORD ARSENAL LOT "C"—WINNER

	600 yds.	1,000 yds
Mean Radius	2.57	8.42

Figure of Merit—6.47

1922—FRANKFORD ARSENAL LOT NO. 1—WINNER

	600 yds.	1,000 yds
Mean Radius	3.18	7.22

Figure of Merit—5.873

1923—FRANKFORD ARSENAL TYPE "C"—WINNER

	600 yds.	1,000 yds
Mean Radius	2.850	6.662

Figure of Merit—5.391

1924—FRANKFORD ARSENAL LOT NO. 1—WINNER

	600 yds.	1,000 yds
Mean Radius	2.26	5.685

Figure of Merit—4.543

The pistol ammunition used in 1922 was selected from one of the best lots of war-time manufacture. The method used for determining the winning ammunition for 1923 was different from that used for the 1924 pistol ammunition, so that a direct comparison of the figure of merit is impossible.

It is very interesting to note the improvement in the ammunition in the last three years, and to compare it with the specifications under which the caliber .30 ammunition was manufactured during the war. During the war, the specifications permitted the acceptance of caliber .30 ammunition which gave a mean radius of 7½ inches at 500 yards when fired in a standard rifle. This would correspond to approximately 6-inch mean radius if fired in a Mann barrel.

The remarkable improvement in accuracy of caliber .30 ammunition shown by the above tests has been brought about, to a large extent, through the effort to supply a super-accurate ammunition for the National Matches.

Test of International and Palma Match Ammunition

The International and Palma Match ammunition was tested by the Board at Aberdeen Proving Ground, Aberdeen, Md., December 17 and 18, 1923.

An invitation was given to all commercial loading companies to submit ammunition for this test. At this test, the Remington Arms Company, Inc., the Western Cartridge Company and Frankford Arsenal were represented. Each company was permitted to submit not to exceed two sample lots for the International test and two sample lots for the Palma test.

INTERNATIONAL MATCH AMMUNITION

The International test was held at 300 yards. The following types of ammunition were submitted for this test.

Remington Lot No. 2—Winner

Bullet—180grain, flat base, cupro nickel.
Powder Charge—46.3 grains HiVel.
Velocity—2610 f. s.
Pressure—46,200 lbs. per square inch.

Remington Lot No. 3

Bullet—180-grain, flat base, cupro nickel.
Powder Charge—50.0 grains EX-1147.
Velocity—2612 f. s.
Pressure—52,020 lbs. per square inch.

Western Lot No. 52

Bullet—180-grain, boat-tail, lubaloy.
Powder Charge—46.0 grains HiVel.
Velocity—
Pressure—

Western Lot No. 62

Bullet—180-grain, boattail, lubaloy.
Powder Charge—49.0 grains HiVel.
Velocity—
Pressure—

Frankford Arsenal Lot AI

Bullet—Type "A," 170-grain.
Primer—Fulminate.
Powder Charge—44.7 grains EX-1147.
Velocity—2477 f. s.
Pressure—37,930 lbs. per square inch.

Frankford Arsenal Lot BI

Bullet—180-grain, flat base.
Primer—No. 70.
Powder Charge—44.7 grains EX-1147.
Velocity—2426 f. s.
Pressure—40,460 lbs. per square inch.

The results were as follows:

MEAN OF 30 TARGETS AT 300 YARDS

REMINGTON LOT NO. 2

	Extreme Vertical	*Extreme Horizontal*	*Extreme Spread*	*Figure of Merit*
Average	2.23	2.128	2.814	2.179

REMINGTON LOT NO. 3

Average	2.197	2.23	2.759	2.214

WESTERN LOT NO. 52

Average	2.787	2.878	3.546	2.833

WESTERN LOT NO. 62

Average	2.965	2.959	3.733	2.98

FRANKFORD ARSENAL LOT BI

Average	3.434	3.299	4.006	3.350

FRANKFORD ARSENAL LOT AI

Average	3.290	3.376	4.138	3.366

The figure of merit for this ammunition is taken as the mean of the extreme horizontal and extreme vertical spreads. This method of measurement was adopted in view of the practical impossibility of measuring the mean radius of the targets since the bullet holes are so close together at this range.

PALMA MATCH AMMUNITION

This ammunition was tested at 1,000 yards. The following types of ammunition were submitted for this test:

Remington Lot No. 1—"Winner"

Bullet—200-grain, flat base, cupro nickel.
Powder Charge—44.5 grains HiVel.
Velocity—2477 f. s.
Pressure—49,180 lbs. per square inch.

Remington Lot No. 2

Bullet—180-grain, flat base, cupro nickel.
Powder Charge—46.3 grains HiVel.
Velocity—2610 f. s.
Pressure—46,200 lbs. per square inch.

Western Lot No. 52

Bullet—180-grain, boat-tail, lubaloy.
Powder Charge—46.0 grains HiVel.
Velocity—
Pressure—

Western Lot No. 62

Bullet—180-grain, boat-tail, lubaloy.
Powder Charge—49.0 grains HiVel.
Velocity—
Pressure—

Frankford Arsenal Lot AP

Bullet—171-grain, Type "A," 9° boat-tail, gilding metal.
Primer—Fulminate.
Powder Charge—48.0 grains HiVel.
Velocity—2735 f. s.
Pressure—48,785 lbs. per square inch.

Frankford Arsenal Lot BP

Bullet—171-grain, Type "A," 9° boat-tail, gilding metal.
Primer—No. 70.
Powder Charge—48.0 grains HiVel.
Velocity—2754 f. s.
Pressure—48,450 lbs. per square inch.

The results were as follows:

Mean of 40 Targets at 1,000 Yards

REMINGTON LOT NO. 1—"WINNER"

	Extreme Vertical	*Extreme Horizontal*	*Extreme Spread*	*Mean Radius*
Average	13.718	13.387	17.126	5.497

WESTERN LOT NO. 52

Average	16.218	14.407	19.087	5.823

REMINGTON LOT NO. 2

Average	14.253	15.875	19.172	6.034

FRANKFORD ARSENAL LOT AP

Average	16.353	16.921	20.764	6.319

FRANKFORD ARSENAL LOT BP

Average	16.955	16.777	21.482	6.627

In the test of International and National Match ammunition, an equal number of targets were fired with each type of ammunition through each of six Mann barrels.

It is very interesting to note the three general types of ammunition submitted: The cupro nickel, flat base bullet by the Remington Company; the lubaloy jacketed, slightly boat-tail bullet by the Western Cartridge Company; and the gilding metal jacketed, 9° boat-tail bullet by Frankford Arsenal.

The International Matches will be held at Paris the latter part of June, 1924, and the National Matches at Camp Perry during September.

In the last few years the impression has been created that when gilding metal jacketed ammunition follows the firing of cupro nickel jacketed ammunition, the accuracy of the former is impaired. To determine whether this was the case exhaustive tests were run at Frankford Arsenal and at Aberdeen Proving Ground. These tests showed conclusively that there is no falling off in accuracy when bullets of different types of jackets are fired, providing the barrels are thoroughly cleaned at the beginning of each target.

These annual tests of National and International Match ammunition serve the very useful purpose of stimulating the Ordnance Department and the commercial manufacturers of powder and ammunition to devote their best efforts to turning out the most accurate ammunition possible.

Advantages of Hydro-Pneumatic Recoil Mechanisms

By

D. A. GURNEY and W. C. YOUNG

PREVIOUS to the World War our mobile artillery employed hydro-spring recoil mechanisms entirely for dissipating energy of recoil and returning the gun to battery. The advantages of this type of mechanism were discussed in the July-August, 1923, issue of ARMY ORDNANCE in comparison with hydro-pneumatic recoil mechanisms, with the general conclusion that the hydro-spring mechanism is preferable for calibers of mobile artillery below the 6-inch gun and 8-inch howitzer, with the possibility of their use even for these calibers. In view of the great post-war development of mobile artillery which is now being carried out, the further discussion of these types of recoil mechanisms is of considerable interest at this time.

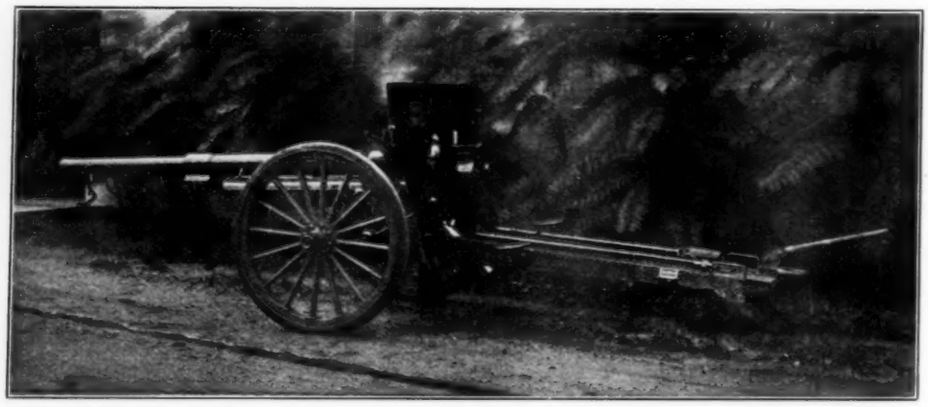


Fig. 1. 75-mm. Gun Carriage, Model 1921 E; left side, zero elevation and traverse

The hydro-pneumatic recoil mechanism has been used in all experimental and mobile artillery developed since the World War from the 75-mm. pack howitzer up to and including the 155-mm. gun and 8-inch howitzer and anti-aircraft artillery matériel. There are in service 75-mm. guns, Model 1897, 155-mm. guns and howitzers, Model 1918, 8-inch howitzers, 240-mm. howitzers and 9.2-inch howitzers, all of which have hydro-pneumatic types of recoil mechanism. Hydro-spring mechanisms have been used in experimental types of smaller caliber due to the small size of springs which can be used in these designs, and to the fact that we have thus far been able to meet the requirements for the relatively low powered infantry weapons by the use of the hydro-spring mechanism.

Greater Range and Less Weight Required

The principal feature of mobile artillery carriage design today is the constant requirement to produce matériel capable of far greater range than artillery used in the World War, and with the further requirement that it shall have the same, or even less, weight. The ranges of this matériel are approximately 50 per cent greater than artillery used in the World War. The materials employed in construction are in general no better, and in some cases the quality of material has been reduced to permit the use of commercial supplies, from which it will appear that very difficult design problems have been encountered. Notwithstanding these exceptional requirements, matériel which approximately fulfills them has been actually constructed and tested and has been found to stand up under test better than might be anticipated. It has been made possible to meet these severe requirements by the use of hydro-pneumatic recoil mechanisms to dissipate the energy of recoil and return the gun to battery.

The discussion in regard to the relative merits of these two types of mechanism centers about the divisional gun, since it is admitted that the relative advantages claimed for the hydro-spring mechanism diminish as the caliber increases. A comparison of the characteristics of the 75-mm. Field Gun, Model 1916, and the 75-mm. Field Gun, Model 1921, is shown on Table I. The relative amount of metal in the two mechanisms is shown by the sections shown in the diagram (Fig. 3). These particular guns were selected because the Model 1916 gun is the latest divisional gun having a hydro-spring recoil mechanism designed by the Ordnance Department, and, so far as the recoil and counter recoil mechanism is concerned, it represents the most advanced development yet attained in this type of mechanism. For purposes of comparison, adjustment should be made in the weight due to the fact that it was designed for variable recoil, and this will be discussed further on. The 75-mm. Gun, Model 1921, represents a recent development in hydro-pneumatic recoil mechanisms and was selected because its elevation corresponds very closely to that of the 1916.

As stated above, for comparison, an adjustment should be made in the weight of the assembled cradle of the Model 1916 on account of the fact that it was designed for variable recoil and hence the recoil cylinder is slightly heavier than would be required for long recoil alone. This adjustment would, however, amount to only a few pounds, and in the case of the Model 1921 is offset by the fact that for this recoil mechanism a liquid pump is contained in the cradle which would be eliminated on future designs. Based on this comparison it will be observed that the weight of the hydro-spring mechanism is actually 56 per cent greater than that of the hydro-pneumatic mechanism, although it has to do considerably less work in that it returns only the 765-lb. gun to battery, while the hydro-pneumatic mechanism returns a gun weighing 942 pounds at approximately the same elevation. If the weight of the assembled cradle, 476 pounds, is multiplied by the ratio of the weights of the two guns, namely 942/765, the weight of a hydro-spring mechanism suitable for returning the 1921 gun to battery will be found to be 587 pounds, an increase over the weight of the present Model 1921 of 92 per cent.

TABLE 1

Characteristics		75-mm. Gun M. 1916	75-mm. Gun M. 1921
Weight of projectile	lbs.	15 *	15
Muzzle velocity	ft.-sec.	1,700 *	2,175
Maximum range	yds.	10,000	15,000
Maximum pressure	lbs. per sq. in.	36,000	34,000
Weight of charge	lbs.	1.6	2.68
Length in calibers		28.4	42
Maximum elevation	deg.	53	50
Recoil	in.	46-18	42
Weight of gun	lbs.	765	942
Weight of assembled cradle	lbs.	476 **	305

* Designed for.
** Without range scale bracket and variable recoil mechanism.

The hydro-pneumatic mechanism is generally preferred by Field Artillery officers on account of its freedom from maintenance difficulties and its smoothness of action. The characteristics which determine the smoothness of action of the recoil mechanism are rather indefinite and difficult to measure. They are influenced more or less by the stability of the carriage, the speed of action of recoil and counter recoil, etc. It is probable that the general reputation which the hydro-pneumatic mechanism has for acting smoothly is based on the counter recoil action, which is relatively slow as compared to hydro-spring mechanisms used in the past. It is, of course, entirely practicable to so design a hydro-spring mechanism that the springs will return the gun to battery under control of a buffer at any desired uniform speed. This has, however, not been attempted in the past with these mechanisms, except in the 75-mm. gun carriage, Model 1916 (split trail), and to provide such smoothness of action would require shop adjustment of each mechanism as is done in the case of the hydro-pneumatic mechanism. Under such conditions the hydro-spring mechanism would lose one of its principal advantages, viz: simplicity and ease of manufacture.

The hydro-pneumatic design does not approach the hydro-spring design for simplicity. It is necessary to provide in the hydro-pneumatic a floating piston which separates the nitrogen or air from the oil in the recoil cylinder. Cylinder heads must be provided which do not permit leakage of oil even when this oil is maintained for years under a pressure in excess of 100 atmospheres. These features require systems of packing that are of necessity more complicated than similar packing used in the hydro-spring mechanisms. The necessity for preventing leakage and also to provide uniform frictions which are measured in assembling requires manufacture of cylinders and piston rods with a lapped, or mirror-like, finish, which is not ordinarily used in commercial work. Certain parts of the packing must have a very close fit, and in certain cases select assemblies must be resorted to. It must be borne in mind, however, that while these features increase the initial cost, the durability and reliability of the completed mechanism undoubtedly outweighs the difference in initial cost.

Standardization

The hydro-pneumatic mechanism affords opportunities for standardization to a much greater extent than that found with springs. In many cases guns of widely different design may use the same sizes of cylinders and, consequently, the same cylinder heads, floating pistons, recoil piston packings and stuffing box packings. This has actually been accomplished in several of the experimental carriages thus far designed and manufactured. It is manifestly impossible to do any such standardization work when using springs as it has always been found that a counter recoil spring designed for one carriage cannot be used in another even of slightly different type. A large number of small parts, such as counter recoil valves, filling and drain valves, liquid and air pumps, oil screw fillers, etc., are also capable of being standardized. This affords an excellent opportunity for large mass production on certain parts and tends to offset the excess cost of the hydro-pneumatic system.

The design of hydro-pneumatic systems, while it is in its infancy so far as this country is concerned, has been as well if not better standardized by the French, who have manufactured this type of mechanism for a great many years. Fortunately, as a result of the World War, we have obtained practically all the design and production information needed for our use, and it cannot be maintained that the elements of design are more difficult in the case of the hydro-pneumatic than in that of the hydro-spring mechanism. Calculations are comparatively simple, and are based on the known behavior of gas

under pressure and of liquid when being forced through orifices. Packing frictions can be predicted with accuracy and may be adjusted to any desired amount, and means are provided during manufacture for measuring and adjusting them.

While it is true that considerable modification of pilot recoil mechanisms has been found necessary during proof test, this is also true of hydro-spring mechanisms of new design. Those familiar with the difficulties experienced with the recoil mechanisms of the Model 1908 howitzer carriages, and with the development of the recoil mechanism for the 75-mm. Gun, Model 1916, will recognize this fact. In the case of the latter gun, even after development was supposed to be complete, it was found that mechanisms manufactured by different organizations did not function in the same manner, and changes were necessary in recoil throttling orifices during war production. In the case of the 3-inch A. A. Carriage, Model 1918, the design was never satisfactorily perfected, and for these reasons these mechanisms have never been satisfactory. In general, it may be said that a mechanism of either type must be subjected to test and certain modifications made before it is found satisfactory, and that the action of a hydro-pneumatic mechanism may be predicted as well, if not better, than that of a hydro-spring mechanism.

Manufacture

The manufacture of hydro-pneumatic mechanisms requires a great many facilities which do not exist for commercial work. This particularly applies to the lapping machines needed to obtain a mirror-like finish in the cylinders. Such facilities were provided during the World War for production of the 75-mm. gun recoil mechanism, Model 1897 (French), 155-mm. howitzer mechanism, Model 1918 (Schneider), 155-mm. G. P. F. gun mechanism, Model 1918, and for the 240-mm. howitzer mechanism, Model 1918 (Schneider).

The manufacture of any recoil mechanism would require special facilities but in the hydro-spring type the special facilities would have been less. However, the procurement of suitable springs in this country has in the past been very difficult. The size of the springs

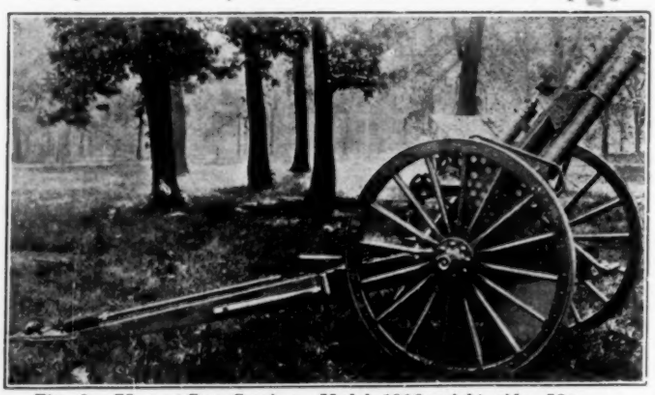


Fig. 2. 75-mm. Gun Carriage, Model 1916; right side, 53° elevation; extreme left traverse.

required and the high fiber stress necessary has caused them to be difficult to manufacture by processes now in use. This feature of procurement has been strongly emphasized both in pre-war carriages and in the carriages of hydro-spring type built during the war. Difficulty has also been experienced with certain experimental carriages in obtaining satisfactory springs. If it be assumed permissible to reduce the fiber stress in counter recoil springs, this will result in an increased advantage for the hydro-pneumatic mechanism since the weight of springs varies inversely as the square of the fiber stress, and an increase in the size of the spring due to lower fiber stress will require also an increase in the weight of the spring cylinders, etc. The manufacturers of counter recoil springs demand a wide tolerance in the load at

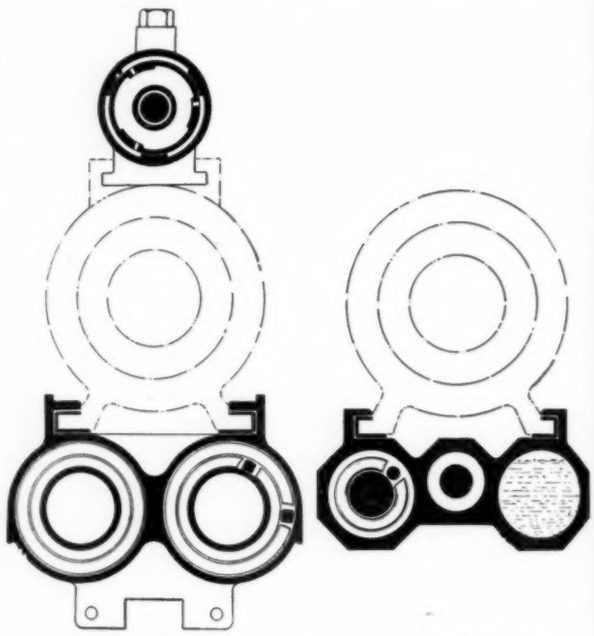


Fig. 3. Diagram of recoil mechanisms in 75-mm. Gun, Model 1916 and Model 1921.

assembled height, and consequently the action of the counter recoil mechanism is not definitely determined as the return to battery will be faster with a spring having a high load at assembled height than it will with a spring in which this load approaches the minimum prescribed. This condition is aggravated due to loss of strength in springs in storage and in use.

The necessity of secrecy regarding the design and methods of manufacture of some of the hydro-pneumatic recoil mechanisms has caused some difficulties, particularly in the introduction of this type of mechanism, and in its manufacture. These difficulties are not particularly great, however, and they have been met in production as is evidenced by the number of satisfactory mechanisms which were built during and after the World War.

Service Use

In service use it is found that the hydro-pneumatic recoil mechanism is much more reliable and has a far greater certainty of action than the hydro-spring. This opinion of results in service use is generally concurred in by the artilleryman who has had service with materials using both the hydro-spring and hydro-pneumatic mechanisms. In the latter, the service has a mechanism which can be depended upon and which requires practically no maintenance on its part. The main item of upkeep in the battery is the replacement of the oil or other liquid used in this recoil mechanism. In the rare cases of failure to function which do occur the unit is replaced by another while the mechanism is being repaired. During the World War, when the hydro-pneumatic recoil mechanisms were subjected to the most severe use of continuous firing, replacement of oil and minor malfunctions which could be adjusted in the field were practically all the maintenance required.

It is fairly well established that the French 75-mm. mechanism may be expected to stand up for 20,000 rounds without any major difficulty, and some have been fired a greater number of rounds without overhaul. It is very doubtful if any hydro-spring mechanism would endure more than 5,000 rounds without replacement of springs. Breakage of springs is a very frequent occurrence. For example, recently in a short target practice of 75-mm. guns, Model 1917 (British), 75 per cent of the springs in the battery broke during that practice.

It is interesting to note the results met with in the use of the 18-pdr. gun carriage, which has a hydro-spring recoil mechanism identical to the 75-mm. gun carriage, Model 1917 (British), during the World War. The replacement of springs ran to a rather high percentage. From the observation of a considerable number of carriages under these war conditions the replacements of springs required were very considerable. Assuming the life of the 75-mm. gun to be about 14,000 rounds, reports indicate that during the life of every four guns over 200 springs required replacement.

In cases of failure of the hydro-pneumatic mechanism to function in action which cannot be adjusted in place the whole carriage should be removed for further overhaul and a spare put in its place. In case a minor repair only is required the piece can easily and quickly be put back in action. The repairs and adjustments required in the field are usually minor and such that can be made in a short time. The mechanisms which require work at a base shop or an arsenal are usually worn out or have been damaged by enemy fire. These causes cover practically all the more serious cases of repair that are required. This was found to be the case during the World War in practically all units using this matériel.

Advantages of Major Importance

The following advantages of major importance are claimed for the hydro-pneumatic mechanism as opposed to the hydro-spring:

(a) Simpler maintenance by field troops;
(b) Greater durability;
(c) Greater reliability;
(d) Lower weight for all calibers, including divisional;
(e) Smoother action.

The above advantages are called major because they deal with the action of the mechanism as it is actually used by the field troops. In addition, the hydro-pneumatic mechanism possesses the further advantage, which might be termed minor, of affording better opportunities for standardization. The advantages claimed for the hydro-spring mechanism in the article above referred to deal almost entirely with the mechanism in the course of design and production, and maintenance in storage, and for these reasons these advantages are considered minor.

Colonel Walsh Appointed Head of New York District Ordnance Office

MAJOR GENERAL C. C. WILLIAMS, Chief of Ordnance, announced on December 8, 1923, the appointment of Colonel James L. Walsh as Chief of the New York District Ordnance Office. Colonel Walsh succeeds Brigadier General John Ross Delafield, who resigned the position upon his recent election to the presidency of the Reserve Officers Association.

The new chief of the New York District is a graduate of the United States Military Academy, Class of 1909, and during the World War served as Assistant to the Chief of Ordnance. He served as the first permanent secretary of the Army Ordnance Association from 1919 to June, 1922. He established ARMY ORDNANCE in 1919, and to him is due much of its initial success and present standing. Colonel Walsh retired from the Regular Army in 1922 and is now associated with the Bankers Trust Co., New York.

UNDERWOOD & UNDERWOOD

Col. James L. Walsh

He brings to the New York District a wealth of experience and a broad understanding of Ordnance. Having held assignments of importance during his military career and having been in intimate contact with the problem of industrial preparedness during the World War, he is well equipped to assume the duties of this very important post.

Colonel Walsh was awarded the Distinguished Service Medal with the following citation:

"For exceptionally meritorious and distinguished services in a position of great responsibility, first as chief of the Personnel Division, Office of the Chief of Ordnance, which he organized and administered with conspicuous success during the first nine months of the war, a critical period during which all Ordnance activities depended upon the successful handling of the personnel problem; and later as personal and executive assistant to the Chief of Ordnance, in which capacity his breadth of vision, tact, sound judgment, and loyalty, were invaluable to the Government in the numerous highly confidential matters entrusted to his care. In each of these positions his services to the Government were highly conspicuous and eminent."

To the new chief of the New York District ARMY ORDNANCE extends its hearty congratulations, being confident that his administration of that office will be as successful as were his accomplishments while in the military service and his pioneer work in the Army Ordnance Association.

New Telescopic Musket Sights

By

H. K. RUTHERFORD

IN the July-August, 1921, issue of ARMY ORDNANCE, there appeared an article by the present writer on the subject of Telescopic Musket Sights. This article reviewed the progress that had been made up to that time in developing a suitable instrument for the service and made certain recommendations regarding the direction which it was thought future development should take. These recommendations were subsequently approved by the Ordnance Department, Technical Staff, and Frankford Arsenal was authorized to proceed with the development of two different types of sight in accordance with the conclusions of the article. These sights have now been completed and tested by the Ordnance Department and forwarded to the Infantry Board for further consideration. The present article is written with a view to describing in detail the characteristics of the two new sights and indicating wherein improvement may be made in the designs in case of future manufacture.

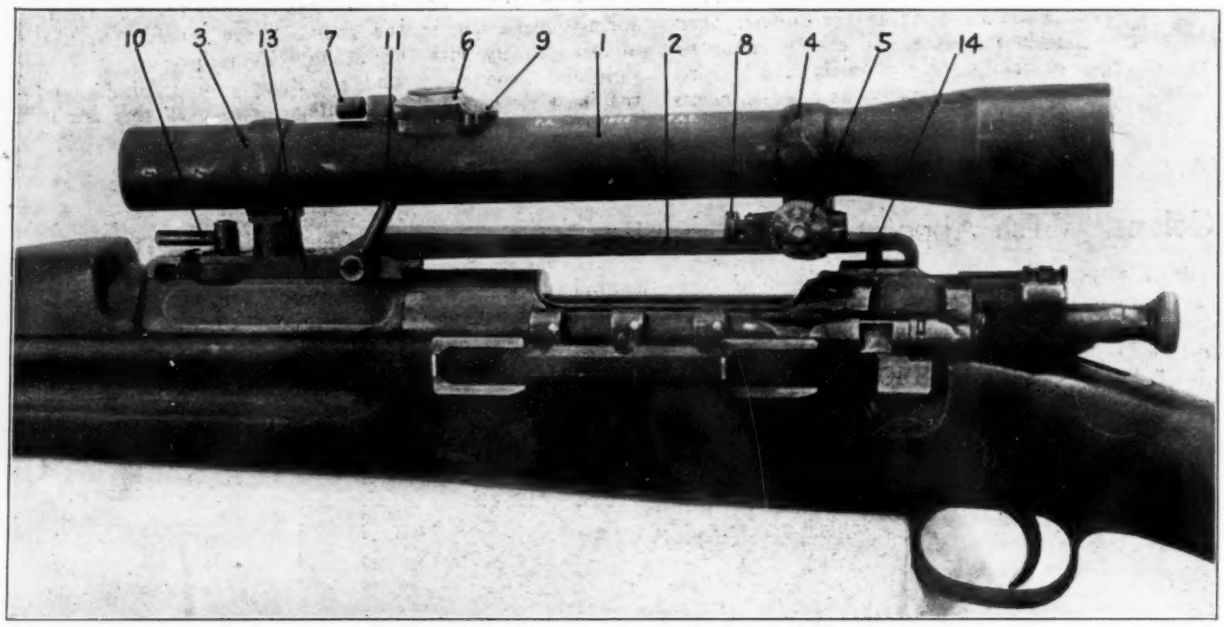


Fig. 1. The New Telescopic Sight in position on the Springfield Rifle

In the article above referred to it was brought out that the most practicable type of telescopic musket sight for our service would probably have the following characteristics: A straight telescope similar in design to Frankford Arsenal No. 7, as compact as practicable to obtain the optical characteristics outlined below, mounted rigidly on a bracket adapted to easy attaching to any service rifle without requiring any modification to the latter. The mounting was to be such that the telescope could be removed and replaced on the rifle at will without any change in the targeting adjustment. Range was to be set by moving the reticule of the sight and windage by motion of the telescope as a whole on its bracket. The optical characteristics were to be as follows:

Power about	2.5
True field	8 to 10 degrees
Exit pupil	.25 to .30 inch
Longitudinal eye relief	2.75 to 3 inches

The right side of the new No. 9 sight and mounting as developed to meet the above specifications and in position on the caliber .30 rifle is shown in Fig. 1.

As shown in the illustration, the telescope is of the straight type permanently attached by bearings at either end to a rigid bar, this bar being arranged at one end to clamp into the rear sight fixed base of the rifle and at the other end to make contact with bridge of the receiver without clamping.

The telescope of the new sight has the following optical characteristics:

Power	2.5
True field	9 degrees
Exit pupil	.27 inch
Eye relief	2.7 inches

It is of the universal focus type, no provision being made for focusing either the objective or the eyepiece by the user.

The telescope tube 1 is attached to the bracket 2 by means of two collars, viz., a front one 3, the lower end of which is pivoted in the bracket 2, and a rear one 4, the lower end of which passes through a transverse slot in the bracket 4, thus permitting the windage screw 5 to rotate

the whole tube about the pivot at 3 when setting deflections. Spring washers are placed at the lower ends of both bearings 3 and 4, between them and the bracket 2, to compensate for any lost motion or wear that may occur. A coil spring is provided to oppose the motion of the windage screw 5, and removes all lost motion from this mechanism.

The range knob for moving the reticule of the telescope in the vertical direction is shown at 6. Combination counting and locking devices for the range and windage knobs are shown at 7 and 8 respectively. When these locks are screwed home, no movement of the knobs is possible. When they are released, the passage of the serrations of the knobs over a spring detent in the housings of 7 and 8 indicates by sound the amount of movement of the knobs. Since the serrations on range and windage knobs are accurately spaced one minute apart as measured by the corresponding movement of the telescope, this affords a ready means of adjusting the aim without looking at the graduations.

The range dial 6 is graduated in yards from 0 to 1400. A correction scale 9 is provided for use in conjunction with the range dial and is graduated so that each division corresponds to one minute of change in range. Corrections in range may thus be made in terms of minutes of elevation either visually by use of the scale 9 or audibly by use of the counting device above referred to.

The deflection knob 5 is graduated so that each division corresponds to one minute of angular movement of the telescope.

The telescope bracket 2 consists of a bar as rigid as practicable for the weight of metal contained in it. At its forward end, it is adapted to fit into the recess provided in the rifle for the rear sight movable base and carries the two clamping levers 10 and 11, locking it in place on the rifle. The clamping device 10 is adapted to engage with the rear sight pivot on the rifle and, regardless of slight variations in diameter of this pivot, to make firm connection to it. The clamping device 11 serves to grip the rear lug of the rear sight fixed base firmly between corresponding parts on the bracket 2 and thus to lock the bracket rigidly to the rifle against any possibility of lateral movement.

A strong leaf spring is located in a recess underneath the portion 13 of bracket, for the purpose of taking up any lost motion between bracket and recess on the rifle.

The rear end 14 of the bracket 21 is provided with a lug or lugs which are designed to make loose contact with the bridge of the receiver on the rifle. These lugs are not essential to the locating of the sight on the rifle and may, in fact, be omitted, but were added as a safety feature to prevent any accidental blow at the rear end of the telescope from being transmitted to the fastenings at the front end, where it might disturb the adjustment of the sight or damage the connecting parts.

It will be evident, therefore, that the sight is held to the rifle by the attachment at the forward end of the bracket only, the body of the bar 2 being sufficiently rigid to give the required support to the rear end of the telescope without assistance from the lugs at 14. While this construction would seem to place too much dependence on the clamping mechanism provided, it has been found in practice that the method is entirely reliable.

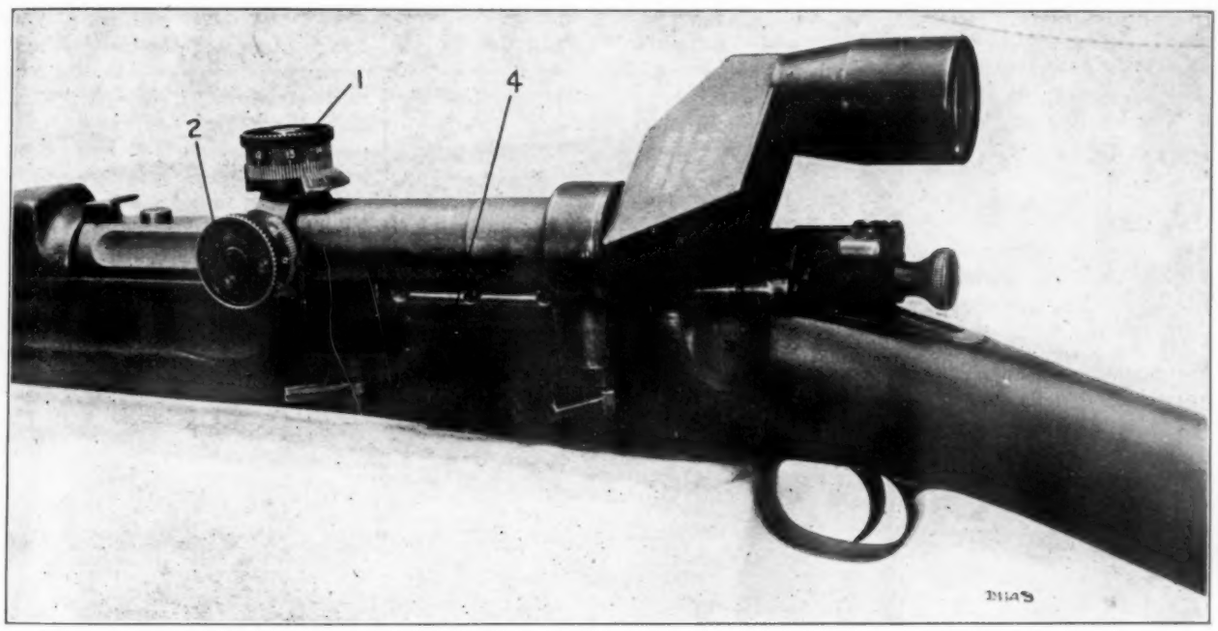


Fig. 2. Telescopic Sight No. 10 mounted on the Springfield Rifle

Some thousands of rounds have been fired with this sight using a full service charge and no weakness, loss of adjustment, or change in position of the sight on the rifle has been apparent. The sight has repeatedly been removed from the rifle in the midst of a string of shots and then replaced with no perceptible change in the location of the center of impact. The sight may be placed on any caliber .30 Springfield rifle, after the iron sight is removed, without any modification or fitting whatever in rifle or sight.

This sight apparently comes very near to fulfilling all the conditions for an ideal telescopic musket sight for our service. With the exception of weight only, it meets or can, by trifling modifications, be made to meet very closely every requirement laid down by the Infantry Board as expressed in its exhaustive report on the subject under date of June 30th, 1923.

The weight of the new sight, including bracket, is about 1 pound 8 ounces, but it seems probable that at least 4 ounces of this weight may be saved by refinements in

design which it did not seem advisable to make when the original design was prepared. The object was to obtain a sight which would meet certain conditions and be thoroughly reliable, weight being of secondary importance. It is believed that there will be no great difficulty in refining the new sight to come close to meeting the weight of 1 pound specified by the Infantry Board in its report, without sacrificing any of the desirable features now obtained.

The report of the Infantry Board, referred to, states that a longitudinal eye relief of not less than 3¼ inches is desired, whereas in the new sight this dimension is 2.7 inches. The increased eye relief may be obtained in the new sight by increasing the diameter of the eyepiece, but this change would necessitate raising the whole sight on the rifle in order that the bolt handle might clear the eyepiece. It is, of course, very desirable to keep the telescopic sight as low on the rifle as possible. Since the desirable quality of longer eye relief can then be obtained only at the expense of making the position of the sight on the rifle less convenient to the user, it appears that the using service should decide just what compromise between these opposing factors should be reached.

In addition to reducing the weight of the sight, it will be entirely practicable to split the collars 3 and 4 which attach the telescope to the mount and provide screws by means of which the telescope will be clamped into these collars. This arrangement would permit the user to adjust the telescope along the axis of the rifle to suit his particular holding position. Like all such optional adjustments, however, it is likely to be poorly made in the service and to result in more trouble than was caused by the difficulty it was intended to overcome, and for this reason, it is believed that greater satisfaction will be obtained by omitting all such adjustments and constructing the sight as a strictly rigid mount as shown in the illustrations.

Figure 2 shows the offset type of sight recently completed for comparative test with the straight type shown in Figure 1, as recommended in the previous article on this subject. As shown, the body of this telescope is carried by a separate bracket 4 screwed to the left side of the receiver of the rifle and the eyepiece is offset from the body so as to bring the line of sight over the center of the piece.

The usual range and deflection screws are shown at 1 and 2 respectively. Both of these operate by moving the body of the telescope about a ball and socket joint in the rear support 3. Springs are provided to oppose the motion of these screws and compensate for the effect of wear or lost motion. Locks are provided to prevent accidental change of either of these adjustments.

The optical characteristics of the offset type of sight shown are practically the same as those of the straight type above described.

The cost of manufacture of the offset type with its bracket is, of course, considerably greater than that of the straight type and on account of the unbalanced forces acting on the former, it cannot be depended upon to remain indefinitely in adjustment as can the straight type.

The report of the Infantry School, above referred to, states that the value of the features of clip loading and the possibility of instantaneous interchangeability of telescopic with iron sights obtained in the offset type, is nil. The positive disadvantage of greater cost, less reliability, lack of interchangeability on different rifles without modification of the same, with the absence of any compensating advantages, condemn this type of sight for service use in comparison with the straight type above described.

When a few minor changes, such as reduction in weight, refinement in design to adopt it to production in quantity, and modification in some details such as the reticule to meet the desires of the service, it appears that the sights shown in Figures 1 and 2 can be made entirely satisfactory from the standpoint of the service as well as that of the Ordnance Department.

Progress in Fixed Nitrogen Research

Fixed nitrogen research in this country is steadily going ahead, according to the annual report of the Fixed Nitrogen Research Laboratory for the year ended June 30, 1923.

The report contains a good historical account of the occurrences immediately following the Armistice which led up to the establishment and operation of the Laboratory by the Ordnance Department and its subsequent transfer to the Department of Agriculture.

The narrative of technical accomplishments is interesting. A comprehensive study has been made of the stability of calcium carbide at high temperatures which seems to indicate that the cyanamide plant at Muscle Shoals may yet be turned into an economic asset. Cyanide also has been given much study and thought by the Laboratory.

The Haber process however has come in for the lion's share of the activities of the laboratory and in this field the staff has made some very noteworthy contributions. Principal among these is the development of a new and extremely reactive catalyst. Indications are that an even more satisfactory catalyst will be forthcoming shortly. The principal interest of the organization in this process however has been a solution of the problem of producing cheaper fertilizer. As the report points out, this factor is greatly dependent upon the possibility of sustained high pressures, and considerable work, notably on the examination of alloy steels, has been done during the past year.

The arc process also has been the subject of some research studies that have been made of the electric discharge in the gases and the thermal processes involved.

Dr. Cottrell, Director of the Laboratory, and his staff of capable assistants, have rendered an excellent account of their work for the year. It is to be hoped that as much constructive progress in this vital field can be accounted for in each succeeding year. It is gratifying to know that this research work, so closely allied to Ordnance development and manufacture, is progressing apace with the other industries of the world.

Fire Risks With Ammonium Nitrate*

By

J. L. SHERRICK

ON September 21, 1921, a disastrous explosion occurred at Oppau, Germany, under conditions which indicated that large quantities of a double salt of ammonium sulphate and ammonium nitrate detonated under the influence of a blast of some explosive. There have been other occasions in which masses of ammonium nitrate have detonated under the influence of fire or explosives,[1] such as the Repauno explosion, the Morgan fire and explosion, and others.

The use of ammonium salts in the fertilizer and explosives industries has grown to enormous proportions in late years. In the manufacture of permissible explosives during the year 1921, a total of 21,381,500 pounds of industrial ammonium nitrate was used, while in 1920 the total was 31,831,000 pounds.[2] It is not surprising that the occurrence of such explosions as those mentioned should cause, in the interest of safety, considerable concern to the users of ammonium nitrate, the transportation companies, and the various underwriters' associations.

Since the information available in the literature on the explosibility of ammonium nitrate was from scattered tests by various investigators, and likewise incomplete; and since it was almost impossible to correlate the results of such tests, it was felt that a systematic investigation should be undertaken to procure more precise information on the subject. Such an investigation was desirable, not only from the standpoint of safety, but also for the protection of the manufacturers and users of ammonium nitrate from unnecessary restrictions.

The National Research Council Committee On The Explosibility Of Ammonium Compounds

This research was undertaken at the suggestion of the National Research Council which appointed a special committee on Investigation of the Explosibility of Ammonium Compounds.

The members of this committee are: Charles P. Beistle, Bureau of Explosives, A. R. A.; C. A. Bigelow, Institute of Makers of Explosives; J. L. Sherrick, Bureau of Mines; Charles E. Munroe, National Research Council; C. G. Storm, Ordnance Department, U. S. A.; F. G. Cottrell, Director, Fixed Nitrogen Research Laboratory; and George W. Patterson, Naval Proving Ground, Indian Head, Maryland.

The work herein reported was done under the direction of this Committee, and in accordance with the plan outlined by them.

Materials Used In The Investigation

Since the course of the decomposition of ammonium nitrate is influenced by impurities, it was deemed advisable to use a good grade of industrial ammonium nitrate as representative of the large quantities handled in storage and transportation in the industries.

Ammonium nitrate.—This was "B. A. S. F. 550" ammonium nitrate contributed by the Hercules Powder Company. It analyzed as follows:

	Per Cent
Moisture	1.20
Insoluble matter	0.097
Ammonium chloride	0.024
Sulphates	None
Nitrites	None

Its physical characteristics were found to be: Color, buff; consistency—granular, coarse, wet, brittle particles, slightly cohesive; shaking density,[3] 0.71.

Firing Devices.—Electric detonators: No. 8 electric detonators, containing approximately a 2-gram charge of a mixture of 80 per cent fulminate of mercury and 20 per cent of potassium chlorate, were used. Electric igniters: These were M. S. electric squibs from E. I. du Pont de Nemours & Company. Fuse: This was Crescent brand from the Ensign-Bickford Company of Simsbury, Connecticut. It burned at the rate of one yard per 87 2-5 seconds. Thermit: This was made up as needed from C. P. ferric oxide and aluminum bronzing powder.

Combustible Material.—Wood Pulp: Grade A wood pulp was used. Charcoal: This material was 200-mesh activated cocoanut charcoal.

Preparation Of The Ammonium Nitrate

The ammonium nitrate as received contained 1.2 per cent of moisture and was decidedly "wet," particularly in the portions near the top, bottom, and sides of the barrel. Since it was desired to have the ammonium nitrate fairly dry, and still retain the crystal size it possessed when received, it was necessary to work out the conditions for drying the salt.

Kortright[4] found that ammonium nitrate deliquesces at 20° C. when the partial pressure of water vapor is greater than 10.8 mm. mercury pressure. This value corresponds to 62.07 per cent saturation.

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* Report II of the Committee on the Investigation of the Explosibility of Ammonium Compounds, National Research Council, conducted in co-operation with the Bureau of Mines. Published by permission of the Director, Bureau of Mines. Reports III and IV will appear in subsequent issues of ARMY ORDNANCE.

1 "The explosibility of ammonium nitrate," by C. E. Munroe: Chem. and Met. Eng., vol. 26, 1922, pp. 535-542.

2 "Production of explosives in the United States during the calendar year 1921," by W. W. Adams: Bureau of Mines Tech. Paper 313, 1922, p. 19.

3 The shaking density of any explosive material is determined, at the Bureau of Mines Explosive Experiment Station at Bruceton, Pa., by the use of an apparatus which consists of a piece of Shelby tube 1¾ inches inside diameter, 1⅝ inches outside diameter, and 12 inches inside length, with a pipe cap on one end; a frame which allows the tube to be raised just two inches, thereby securing a constant height of drop for shaking the tube, and a small plunger which measures the depth to which the explosive has sunk after shaking. The base of the shaking frame is a piece of oak two inches thick and rests on a Trauzl lead block or other non-resilient material. The tube is filled to the top with the material under test. If the material does not flow freely, the tube may be gently tapped to fill it. The tube is then placed in the frame and continually dropped from the 2-inch height until the surface of the explosive no longer sinks by continued shaking. The volume and weight relation gives the shaking density.

4 Kortright, F. L., "The deliquescence of potassium nitrate, sodium nitrate, and ammonium nitrate": Jour. Phys. Chem., vol. 3, 1899, pp. 328-33.

As a building, the temperature of which could be raised to 43° C. (110° F.), was available, experiments were conducted to determine whether the salt could be dried by spreading it out in muslin bottom trays. The experiments were not all inclusive but, using the known vapor pressures of sulphuric acid-water mixtures,[5] it was shown to be possible to so dry the salt when the conditions of humidity outside the building were saturation at 78.8° F.; 75 per cent saturation at 87.8° F.; or 60 per cent saturation at 95° F.

About 200 pounds of the salt were dried in this manner to a moisture content of 0.1 per cent, and then stored in "E. Z." seal glass jars. In the course of this drying the crystal size was not changed appreciably from that of the wet material. After drying and breaking up all lumps the salt was screened, and sizing test, using Tyler screens, gave the following:

Sizing Test on Dried Ammonium Nitrate

Mesh	Per cent by weight
+10	1.66
−10+20	72.40
−20+35	25.27
−35+48	0.37
−48	0.30

Insurance underwriters and transportation companies are interested in the fire hazard connected with the storage and transportation of ammonium nitrate. Any consideration of this fire hazard must concern itself with answering the following questions: Is it combustible? Is it a supporter of combustion? Will its thermal decomposition sustain itself after the source of heat is withdrawn? Will the application of heat in any amount or intensity bring about its detonation?

Tests for Resistance to Fire

The International Commission for the Study of the Unification of the Methods of Tests of the Stability of Explosives,[6] in its report to the Eighth International Congress of Applied Chemistry at Washington and New York, September, 1912, recommended a series of tests for the resistance of explosives to fire. As these tests are being investigated by the U. S. Bureau of Mines to determine their value for the testing of explosives, they were applied in this investigation.

Fuse test.—Three grams of ammonium nitrate, with all lumps broken up, were poured into a glass test-tube (⅞-inch by 7 inches), a uniform surface of the nitrate obtained by gently tapping the tube, and a piece of squarely cut fuse, eight inches long with "spit" end as cut, was introduced into the test-tube so that the end was against the surface of the nitrate. On ignition it was found that the "spit" of the fuse melted only a few granules of the nitrate.

Hemispherical iron-dish test.—This dish, 4 inches in diameter, with a bottom thickness of 0.033 ± 0.007-inch, was heated to redness over a Bunsen burner. One-half (0.5) gram of the loose nitrate was dropped into the dish. As there was no explosion in repeated trials, the charge was increased by 0.5 gram increments until a 5.0 gram charge was used. The nitrate melted immediately, and started to decompose. The melt frothed and at first a very small amount of brownish fumes was given off, but the later fumes were clear and colorless. No residue was left, and there was no flame or detonation.

Red-hot iron test.—After some preliminary trials with smaller quantities, 100 grams of the ammonium nitrate were placed on an asbestos board. The end of an iron bar, 15 mm. in diameter, heated to cherry redness (900° C.), was brought into contact, for over 10 cm. of its length, with the nitrate. The nitrate melted and frothed up around the bar. The fumes given off were clear and colorless until the rod was cooled below red heat, when they were white. Even without withdrawal of the rod the decomposition ceased. There was no flame at any stage of the test.

Table 1

SPECIAL TESTS OF AMMONIUM NITRATE WITH THERMIT

Test No.	Charge	Result
1	1300 grams ammonium nitrate. 120 grams ferric oxide thermit.	The flame was extinguished soon after the thermit reaction ceased. 60 per cent of nitrate was recovered. There was no detonation or explosion.
2	1300 grams ammonium nitrate, 120 grams ferric oxide thermit. A No. 8 electric detonator was placed at the boundary of the thermit and in contact with the nitrate.	The detonator exploded and the container was torn apart but there was apparently no detonation of the nitrate, judging from the sound and the undecomposed nitrate scattered on the ground.
3	1400 grams of a mixture, 12.7 per cent wood pulp and 87.3 per cent ammonium nitrate, and 120 grams of ferric oxide thermit.	Reaction continued until all the mixture was consumed. There was no detonation or explosion.
4	1400 grams of a mixture, 6 per cent wood pulp, 94 per cent ammonium nitrate, and 120 grams of ferric oxide thermit.	The flame was extinguished soon after the thermit reaction ceased and about 60 per cent of the mixture remained.
5	1400 grams of a mixture, 9 per cent wood pulp, and 91 per cent ammonium nitrate, and 120 grams of ferric oxide thermit.	Most of the mixture was consumed. A ½-inch shell of the mixture was left on the sides of the can. There was no detonation or explosion.
6	1300 grams of a mixture, 7 per cent activated cocoanut charcoal and 93 per cent ammonium nitrate, and 120 grams of ferric oxide thermit.	The reaction continued until all the mixture was consumed. There was no detonation or explosion.

The Fire Hazard With Ammonium Nitrate as Indicated by Routine Tests

Since this ammonium nitrate successfully passed all the Commission's tests for resistance to fire we might pronounce it as "insensitive to fire" and its "transportation almost absolutely safe." However near the truth such conclusion may be, the tests themselves tell very little that is really fundamental, and one cannot draw any conclusions as to the element of danger existing under any particular set of conditions. The mere pronouncement of this material as "safe for transportation" may even increase the danger, through relaxation of ordinary precautions, unless at the same time the fundamental information concerning its decomposition is presented.

As a matter of fact, the results obtained in these tests do not agree with those obtained by others under similar conditions, as shown in the following extract from a letter, January 6, 1920, by Charles P. Beistle, Chief Chemist, Bureau of Explosives, to Col. B. W. Dunn, Chief Inspector, a copy of which was contained in the Report "Ammonium Nitrate" of the Engineering Department, South Eastern Underwriters Association, Atlanta, Georgia:

"Ammonium nitrate may be detonated by sudden ex-

[5] "Humidity control by means of sulphuric acid solutions," by R. E. Wilson: Jour. Ind. and Eng. Chem., vol. 13, 1921, pp. 326-31.

[6] Report of 8th Inter. Cong. Appl. Chem., vol. 25, p. 261.

posure to high temperature such as by dropping the ammonium nitrate into a heated iron vessel. Tests made a year ago by the Ætna Company showed that 340° C. was about the minimum at which this explosion was produced."

The N. R. C. Committee on the Investigation of the Explosibility of Ammonium Compounds deemed more severe tests desirable and, especially, the determination of the extent to which the decomposition of ammonium nitrate into nitrous oxide and water would sustain itself, and it suggested the use of thermit as the source of heat applied.

Special Tests

Charges of ammonium nitrate and of mixtures of ammonium nitrate and combustible matter were subjected to the heat of the thermit reaction. The ammonium nitrate, or the mixture, was packed at a density of 0.71 in a tinned can, 6 inches in diameter and 6 inches high. In a central core, 1½ inches in diameter, 120 grams of ferric oxide thermit was placed. The assembly is shown in Figure 1. The thermit was ignited by means of a black powder electric igniter primed with a mixture of 50 per cent magnesium powder and 50 per cent potassium chlorate. The results are given in Table 1.

Small lead-block tests, with the charges unconfined, were made with 100 grams of the following mixtures: (1) 12.7 per cent wood pulp and 87.3 per cent ammonium nitrate; (2) 9 per cent wood pulp and 91 per cent ammonium nitrate; and (3) 7 per cent activated cocoanut charcoal and 93 per cent ammonium nitrate. A No. 8 electric detonator was used in each case. No detonation was obtained, and there was no compression of the lead block with any of the three mixtures.

These tests offer further evidence of the relative insensitiveness of ammonium nitrate to fire. In addition, considered in connection with a theoretical analysis of the subject, they may throw light on the general action of ammonium nitrate under other conditions.

Decomposition of Ammonium Nitrate

Ammonium nitrate may decompose in a number of different ways depending upon conditions. Eight different reactions of decomposition are given,[7] as follows:

(1) $NH_4NO_3 \rightarrow HNO_3 + NH_3$
(2) $2NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O$
(3) $NH_4NO_3 \rightarrow N_2O + 2H_2O$
(4) $2NH_4NO_3 \rightarrow N_2 + 2NO + 4H_2O$
(5) $3NH_4NO_3 \rightarrow 2N_2 + N_2O_3 + 6H_4O$
(6) $4NH_4NO_3 \rightarrow 3N_2 + 2NO_2 + 8H_2O$
(7) $5NH_4NO_3 \rightarrow 2HNO_3 + 4N_2 + 9H_2O$
(8) $4NH_4NO_3 \rightarrow 3N_2 + N_2O_4 + 8H_3$

Equations (2) and (3) are particularly important. Equation (2) is usually considered as representing the reaction brought about by detonation; equation (3) represents the main reaction resulting from the thermal decomposition of the salt at from 200° to 300° C.

Consideration of the fire risk would be based upon that reaction of thermal decomposition which gives rise to nitrous oxide and water. Using the heats of formation given by Thomsen, the reaction,

$$\underset{\text{(solid)}}{NH_4NO_3} \rightarrow \underset{\text{(gas)}}{N_2O} + 2H_2O$$

sets free 10,110 calories at constant pressure. Calculating the heat capacity of the reaction products ($C = 24.32 + 0.0123t$), the temperature found is 353° C. at constant pressure. Since this temperature is considerably higher than the temperature (230° C.) necessary for the thermal decomposition of ammonium nitrate, one would expect this reaction to continue when once initiated. Since it has been shown in the tests with thermit that such is not the case, it might be worth while studying the heat quantities associated with each of the various steps in such decomposition.

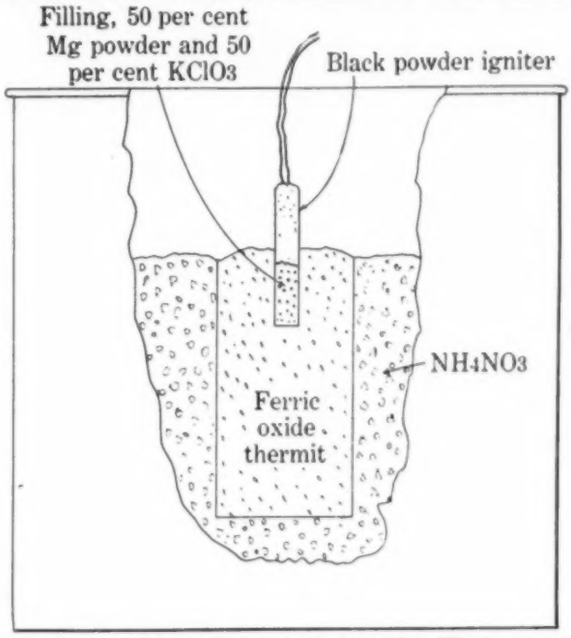


Fig. 1. Thermit Fire Test for Ammonium Nitrate

The equation given deals with the initial and final states at 18° C. In passing from an initial state of NH_4NO_3 at 18° C. to a final state of $N_2O + 2H_2O$ at 230° C., the quantities of heat involved in the various steps are as follows:

(18° C.) $NH_4NO_3 \rightarrow$ (32.1° C.) NH_4NO_3 — 460 calories[7]
Heat of transformation at 32.1° C. from rhombic to monoclinic — 402 calories[7]
(32.1° C.) $NH_4NO_3 \rightarrow$ (84.2° C.) NH_4NO_3 —1,480 calories[7]
Heat of transformation at 84.2° C. from monoclinic to tetragonal — 427 calories[7]
(84.2° C.) $NH_4NO_3 \rightarrow$ (125.2° C.) NH_4NO_3 —1,400 calories[7]
Heat of transformation at 125.2° C. from tetragonal to regular — 950 calories[7]
(125.2° C.) $NH_4NO_3 \rightarrow$ (170° C.) NH_4NO_3 —1,610 calories[7]
Latent heat of fusion at 170° C. —1,680 calories[8]
(170° C.) fused $NH_4NO_3 \rightarrow$ (230° C.) fused NH_4NO_3 —2,180 calories[9]
Total heat quantity from (18° C.) NH_4NO_3 (solid) $\rightarrow$ (230° C.) NH_4NO_3 (fused) —10,600 calories
NH_4NO_3 (230° C. fused) $\rightarrow N_2O + 2H_2O$ (18° C.) +20,700 calories
Total: NH_4NO_3 (18° C. solid) $\rightarrow$ (18° C.) $N_2O + 2H_2O$ —10,600 + 20,700

To raise the products, $N_2O + 2H_2O$, from 18° C. to 230° C. would require,

$$Q = t\,c$$
$$Q = 212 \times (24.32 + 0.0123 \times 212),$$
5710 calories.

[7] M. Berthelot, "Sur la force des matieres explosives d'apres la thermochimie," Third Edition, 1883, vol. 1, pp. 20 to 23. See also J. W. Mellor, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry," 1922, vol. II, pp. 840-841.

[8] The latent heat of fusion has not been determined. The value used for the latent heat was taken by analogy from the values given for other nitrates.

[9] The specific heat of fused ammonium nitrate at these temperatures was assumed to be 0.455 as given by Berthelot.

If, then, 10,600 calories were so applied, externally, at a given point in a mass of ammonium nitrate as to heat one gram molecule (80 grams) of the salt to the decomposition temperature (230° C.) this gram molecule of salt would decompose and free 20,700 calories. If there was perfect heat transference, so that the gases from this first molecule of salt were at about 230° C. on leaving the system 20,700 — 5,710 or 14,990 colories would remain to bring another molecule of salt to the decomposition temperature (230° C.). This 14,990 calories should be more than sufficient as but 10,600 calories are required. The explanation that in spite of this the decomposition reaction is not self-sustaining must lie in an important heat transference from the gas to the salt.

Decomposition of Mixtures of Ammonium Nitrate and Combustible Matter

The admixture of 9 per cent of wood pulp having been found sufficient to make the decomposition self-sustaining, it might be of interest and value to calculate the thermal effects for the various wood pulp and charcoal mixtures, at constant pressure.

(1) 6 per cent wood pulp

$$NH_4NO_3 + 0.014\ C_{15}H_{22}O_{10} \rightarrow$$
$$0.21\ CO_2 + 2.154\ H_2O + N_2 + 0.28\ O_2 + 50{,}413 \text{ calories}$$
$$t = 1314° \text{ C.}$$

(2) 9 per cent wood pulp

$$NH_4NO_3 + 0.022\ C_{15}H_{22}O_{10} \rightarrow$$
$$0.33\ CO_2 + 2.242\ H_2O + N_2 + 0.16\ O_2 + 63{,}135 \text{ calories}$$
$$t = 1512° \text{ C.}$$

(3) 12.7 per cent wood pulp

$$NH_4NO_3 + 0.032\ C_{15}H_{22}O_{10} \rightarrow$$
$$0.48\ CO_2 + 2.352\ H_2 + N_2 + 79{,}040 \text{ calories}$$
$$t = 1713° \text{ C.}$$

(4) 7 per cent activated cocoanut charcoal

$$NH_4NO_3 + 0.5\ C \rightarrow$$
$$N_2 + 2H_2O + 0.5\ CO_2 + 119{,}325 \text{ calories}$$
$$t = 2464° \text{ C.}$$

In view of the relatively large quantity of heat involved in the decomposition of the 6 per cent wood-pulp mixture it is surprising that this decomposition was not self-sustaining. The result shows more strikingly the imperfection of the heat transference. The heated gases escape so rapidly that they leave before they have given up sufficient of their heat to the residual ammonium nitrate to bring it to the point of decomposition, but if there were a solid product of the reaction the retention of this in a highly heated condition might permit of the transference of heat to such an extent that the reaction would be self-sustaining, even with the quantity of heat equivalent to that of the 6 per cent wood-pulp mixture.

This suggests the introduction of a material producing a solid combustion product of which magnesium is an example.

(5) 4 per cent powdered magnesium and 96 per cent ammonium nitrate

$$NH_4NO_3 + 0.14\ Mg \rightarrow$$
$$N_2 + 2H_2O + 0.14\ MgO + 0.43\ O_2 + 47{,}870 \text{ calories}$$
$$t = 1308° \text{ C. (at constant pressure).}$$

The quantity of heat evolved, 47,870 calories, is less than that from the 6 per cent wood-pulp mixture. The temperatures of reaction are practically the same. This 4 per cent magnesium mixture sustained the decomposition of its ammonium nitrate, whereas, the 6 per cent wood-pulp mixture ceased to react soon after its thermit reaction was completed. The ignition temperatures of wood pulp and of magnesium powder are both much below the reaction temperature of 1300° C. When this same experiment was tried with a mixture of powdered aluminum and ammonium nitrate, the decomposition and combustion was not self-sustaining, in spite of the fact that we were dealing with equivalent quantities of heat and equivalent temperatures. This failure of the 4 per cent aluminum-ammonium nitrate mixture to sustain its own decomposition and combustion was probably due to the high ignition temperature of aluminum.

The Detonation of Ammonium Nitrate By Fire

The detonation of ammonium nitrate is conceived of as giving rise to the following reaction:

$$NH_4NO_3 \rightarrow N_2 + 2H_2O + 0.5\ O_2 + 29{,}720 \text{ calories}$$

at constant volume, or + 27,810 calories at constant pressure. The temperatures of reaction are 1110° C. at constant volume, and 870° C. at constant pressure.

This reaction may be conceived of as taking place in two steps:

$$NH_4NO_3 \rightarrow N_2O + 2H_2O + 10{,}110 \text{ calories}$$
$$N_2O \rightarrow N_2 + 0.5\ O_2 + 17{,}700 \text{ calories}$$
$$NH_4NO_3 \rightarrow N_2 + 2H_2O + 0.5\ O_2 + 27{,}810 \text{ calories}$$

Hence, the essential difference between the reaction of thermal decomposition and the reaction of detonation is the reaction represented by the following equation:

$$N_2O \rightarrow N_2 + 0.5\ O_2 + 17{,}700 \text{ calories}$$

at constant pressure, or 17,900 calories at constant volume. The corresponding temperatures are 1800° C. at constant pressure, and 2000° C. at constant volume.

No detonation of ammunium nitrate by application of fire or heat was obtained in any of our tests, and theoretical consideration of the reaction of thermal decomposition indicates that this reaction in itself could never attain explosive violence. Since the detonation of ammonium nitrate is difficult and not self-sustaining except under considerable confinement, it is possible that any detonation resulting from thermal decomposition involves the explosive decomposition of the nitrous oxide first formed.

Considerable information might be gained by working out the conditions under which nitrous oxide itself may be detonated. It has been found possible to decompose nitrous oxide by means of the electric spark and mixtures of it with carbon monoxide have been detonated.[10] It is entirely possible in cases of fire to have explosive gas mixtures formed from the nitrous oxide, resulting from thermal decomposition of ammonium nitrate, and the carbon monoxide and other combustible gases from burning wood. It is further possible that ammonium nitrate in such a gaseous atmosphere would be more sensitive to detonation than when its interstices were filled with air. Some such explosive mixture of gases and ammonium nitrate may have been responsible for the detonation of large masses of ammonium nitrate such as took place in the Morgan explosion,[11] on October 4, 1918. The general subject of the detonation of nitrous oxide and its relation to the explo-

[10] M. Berthelot; work cited.
[11] Charles E. Munroe; work cited.

sibility of ammonium nitrate may well be considered as a phase of the work for future investigation.

Conclusions

1. Ammonium nitrate is not combustible, in the sense that such term is ordinarily used.

The reaction of thermal decomposition, initiated at a point in a mass of the salt at room temperature, will not sustain itself.

It seems obvious that, since the reaction of thermal decomposition evolves a positive quantity of heat, it will be self-sustaining if the entire mass of nitrate be at such a temperature that the heat loss from the system, by conduction and escape of heated gases, is balanced by the heat evolution.*

2. Ammonium nitrate supports the combustion of oxidizable materials.

Its ability to support combustion in any given case will depend upon the initial temperature of the system under consideration, as a whole; the quantity of combustible matter in proportion to the amount of ammonium nitrate; the intimacy of admixture of the combustible matter and the nitrate; and the nature of the combustible material as regards its temperature of ignition, its heat evolution upon combustion and the nature and heat capacity of its combustion products.

3. In the tests herein reported, it was not found possible to bring about the detonation of ammonium nitrate by the application of fire or heat.

4. The importance of studying the decomposition of nitrous oxide and the effect of such decomposition upon the sensitiveness of ammonium nitrate to detonation is indicated by theoretical considerations.

(Report III of this investigation "The Influence of Confinement upon the Explosibility of Ammonium Nitrate" by Dr. Sherrick will appear in the March-April number of ARMY ORDNANCE.)

*NOTE.—This conclusion agrees with the facts observed by Mr. C. A. Bigelow of the Hercules Powder Company and Mr. M. B. Cheney of the Ohio Chemical and Manufacturing Company in connection with the accidental decomposition of ammonium nitrate during manufacturing processes.

A Pilgrimage to Pautzeku

Chinese Bandits Capture an Ordnance Officer

(Continued from page 208)

had taken place. Here we had to wait while thirty or forty of our erstwhile hosts donned their new uniforms and accompanied us out of the valley as a guard of honor. Our beloved chiefs were now brigadier-generals, colonels, majors and all the way down, for 2,700 of them had been taken into the Army of the Republic as a part-price of our liberty. Weeks before the old man with whom I had negotiated for the release of my boy, had explained that they were not *professional* bandits, but had merely done "this desperate thing" to secure the removal of the existing troops who had been making their lives miserable for over a year. But I found that one of the terms included the payment of six months "back pay" for services not rendered! The new soldiers were sights for the gods with their uniform caps perched upon top of their bandit straw hats. If I remember anything about insignia, every man-jack was a lance-corporal of artillery; I often wonder if the Chinese authorities had not cannily marked every uniform to facilitate easy identification later. Not two months passed before several hundred were shot for "mutiny" and just a few days ago I read of the execution of Sun Mei Yao our youthful brigadier for "thinking about" revolt.

At last we were underway again and just as the sun was setting we landed at the military lines and—the *moving pictures!* Poor men; they had been waiting patiently for us for weeks and had we been ten minutes later they'd have been disappointed for the sun waits for no man. It was nine before we reached the mines where the relief train lay. Oh the joy of an honest-to-goodness bath and dinner, the unspeakable bliss of the friendly white faces! At four in the morning away we went for the junction at Linchong. Mr. Anderson, the American who conducted the entire negotiations for the Chinese government, accompanied me to Tienstin, as did Major Philoon, the Assistant Military Attaché. We all owe these men, and several others, a debt of gratitude which we shall never be able to repay.

As we pulled into Tienstin, the track ahead was crowded with soldiers and we found that the President of China had run away from Peking and was being held in his private car until he should sign his resignation and deliver over the seals of his office. After some hours delay (and probably to accommodate Rowlett and myself) he did both, so we all three got home together that night.

It is only natural to ask "When will this kind of thing end?" I cannot answer in a phrase. As you know, China is nominally a republic on the French model. But it is a republic merely in theory, for the only actual authority is concentrated in the hands of three or four "war-lords" backed by three or four million bayonets. The quality of this tremendous military force is so low that the transition from soldier to bandit to soldier and from soldier to bandit seems to involve little difficulty beyond the change of costume. But things must change and out of the muddle of the present must come some form of government which however lacking in other respects, must at least give the Chinaman a right to "life, liberty, and the pursuit of happiness." And in this transition, many will have a part, the missionary, the doctor, the engineer, and the returned native student in his respective profession; last, but by no means least, the honest solid Chinese business man when he once realizes that he owes something to his country other than chasing the "Almighty Mexican Dollar" for himself and his immediate relatives. But China is large, numerous and the most painfully conservative nation on earth. So I imagine that a generation will pass before my son writes any articles for the "Army Ordnance Association" of Shantung!

Author's Note.—Most of the accompanying pictures were taken in the last ten days of our captivity. My wife smuggled my pocket kodak in with a box of crackers.—R. W. P.

The Specific Heat and Thermal Diffusivities of Certain Explosives

PART III

By

A. M. PRENTISS

Probable Error of the Results

Each determination involves the following measurements which are subject to experimental error:

(1) The weight of substance.
(2) Water equivalent.
(3) Temperature change of the capsule.
(4) Temperature change of the water.
(5) The heat subtracted by the capsule.

As the first of these quantities is so easily determined, there could be little doubt concerning it. As the 12 grams of explosive used in each case were weighed to thousandths of a gram, any error in weighing would lie well within one-tenth of one per cent.

The water equivalent of the calorimeter is also free from serious error. Most of this quantity consists of the four-hundred grams of water which was also weighed to thousandths of a gram. The water equivalent of the calorimeter itself was computed by weighing its parts and calculating their heat capacity from their known specific heats. This computed value was also further checked by experimental determination. As the water equivalent of the calorimeter itself was only 3.5 per cent of the total, an error of as much as 3 per cent in its value would be only one-tenth of one per cent of the total.

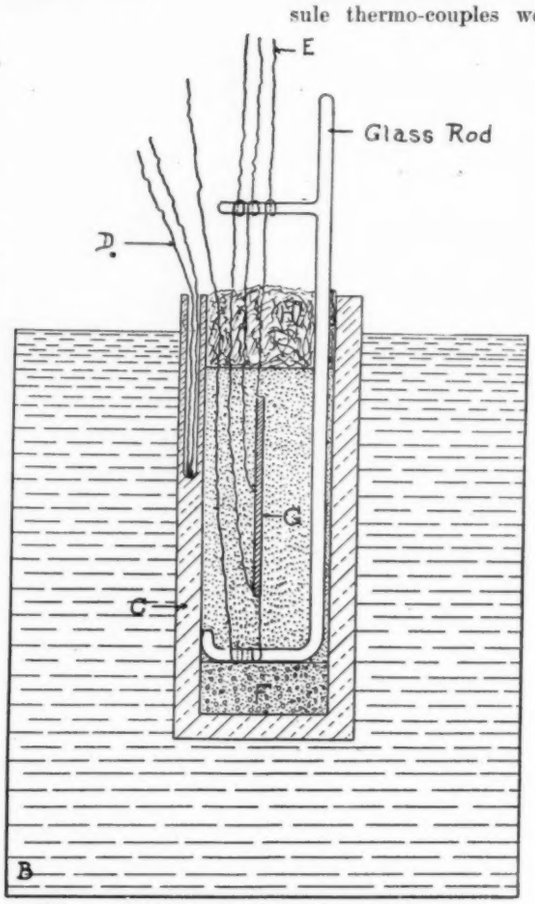


Fig. 6. Apparatus for Determining Temperature Conductivity

Errors in temperature-readings are of greater moment and every effort was made to keep them within the same limits of accuracy. All thermo-electric potentials were measured to 0.5 of a microvolt and in the case of the calorimeter temperatures the readings were interpolated to 0.05 of a microvolt.

In ascertaining the low temperature of the substance, the error could hardly have been greater than plus or minus 0.5 microvolt as the thermo-couple cold was calibrated at —183° (the temperature of boiling oxygen). An error of a microvolt at the temperature of around —190° is equivalent to .06 of a degree, which over a temperature change of some 210° is less than .03 of one per cent, an almost negligible error.

The error in the calorimeter temperature is of about the same order of magnitude. The readings were taken between 20° and 25° and both the calorimeter and capsule thermo-couples were calibrated at 25°. Readings were observed to 0.5 and interpolated to 0.05 of a microvolt. The value of a microvolt at 25° is .0247°. The error of observation could hardly have been greater than plus or minus .05 of a microvolt which is equivalent to .001235°. The average drop of the calorimeter was about 5°, which would reduce the error to less than .03 of one per cent.

The measurement of the heat subtracted by the capsule involves the evaluation of the net effect of heating the capsule and the cooling of the calorimeter during the transference. Here we come to the crux of the problem. It has been shown that these thermal effects could be made to balance and cancel each other by a precise adjustment of the time required to transfer the capsule. It was also found that notwithstanding the exercise of the greatest skill in this operation, the time factor could vary as much as 50 per cent from the minimum. The greatest observed effect upon the calorimeter from such a variation was .005°, which over a range 5° gives a possible error of one-tenth of one per cent. In those cases where the temperature change amounted to something less than 5°, this error would of course amount to a little over 0.1 per cent which is by far the most serious hindrance to accuracy in the process, and in fact constitutes its limit of accuracy. In order to reduce uncertainty of this factor to a minimum, a number of experimental determinations were made in each case until the probable error of the series was within half of one per cent, when calculated according to the method of least squares. While it was realized that the theory of least squares does not fully apply to the average of a small number of determinations, it seemed as good a criterion as any to adopt under the circumstances. In any event an error of less than one per cent in evaluating this

quantity would affect the final results less than one-tenth of one per cent, so that further refinement on this point seemed unnecessary.

In addition to the above errors there must also be considered errors due to possible impurity in the substances tested. Here considerable refinement is necessary because of the many isomeric forms present in nearly all of the nitro-aromatic substances which act as impurities in so far as constancy of physical properties is concerned.

It will be seen from the chemical histories of our substances that the greatest care was exercised in obtaining chemically pure specimens. Furthermore, it is well known from Neumann's rule that the specific heats of compounds are nearly additive, so that one per cent of an impurity present would produce only an exceedingly small effect upon the specific heat. Even when the atomic weight is somewhat different the effect of the impurity would usually not be serious if its quantity did not exceed the experimental limits of one-tenth of one per cent. In view, therefore, of the very excellent chemical preparation of our specimens there could be no serious doubt concerning this point.

The foregoing discussion applies to the limiting errors of the material with which we were working which must always be qualified by the capabilities of the operators for machine-like uniformity of precision in technique and observation. Thus a study of the results shows that deviations of individual determinations from the several averages are sometimes greater than are warranted by the conclusions reached above. The reason for this is to be found in a number of minor contributing factors which cannot be reduced to an exact evaluation. First, due to the irregular currents in the calorimeter caused by the sudden introduction of a very cold mass, the cooling correction cannot be accurately determined, although it is undoubtedly small. Second, a very small drift in the galvanometer, due to the effect of temperature changes on the electrical system and parasitic currents, may occur during an experiment. This cannot be corrected during the run, but may be detected at the end of the experiment and compensated for. Finally, the "human equation" always enters in and can never be fully evaluated.

Determination of Diffusivity

Having determined the specific heats of the substances as outlined above, we pass now to a consideration of the second part of the investigation, viz, the determination of their respective diffusivities.

Diffusivity is generally considered as the equivalent of thermal conductivity, but it is more exactly expressed by the equation:

$$h = k/cs$$

Where h is the diffusivity of the substance, k is the conductivity for heat of the substance, c is the density of loading of the substance, s is the specific heat.

The density (c) is determined at time of loading by dividing the weight of charge by the volume it occupies in the capsule. The specific heat (s) we have just determined. It therefore remains to determine the coefficient of conductivity (k) for each of our substances, in order to solve our equation for diffusivity.

From the general expression for the temperature distribution in an ordinary charge White[1] has deduced the following equation for the time required for a given temperature value to pass from the surface of a sphere of radius R to any point within a distance of r from the center:

$$t = \frac{cs\ (R^2 - r^2)}{6k}$$

Where t is the time in seconds, s is the specific heat, k is the coefficient of conductivity, c is the density of loading.

The spherical form is awkward to work with and when partly immersed in the heating bath, the submerged depth cannot be exactly determined mathematically as the sphere falls under the irreducible case of Cardan's rule. Since powdered substances are usually contained in cylindrical vessels, the above formula can be reduced to apply of infinite length by simply substituting 4 for 6 in the denominator. The cylinder of infinite length is thermally approximated by carefully insulating both ends and neglecting the small loss of heat by infiltration through the insulation. From the formula thus revised we have for the coefficient of conductivity the following:

$$k = \frac{cs\ (R^2 - r^2)}{4t}$$

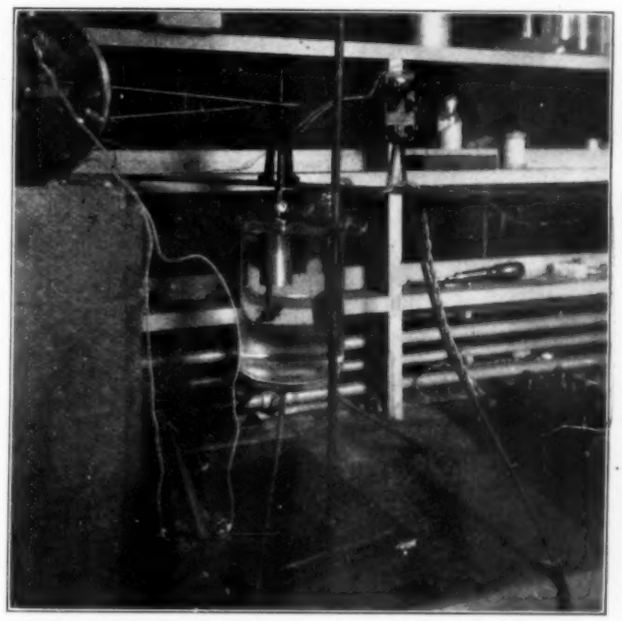


Fig. 7. Diffusivity Apparatus. Note Position of Capsule Containing Explosive Charge

In deducing the above formula White[2] states that in general it may be said that the temperature gradient within a uniform, solid, steadily heated charge approximates a parabola, and the difference of temperature between center and outside for bodies of the same shape is proportional to the first power of the rate of heating and to the square of the diameter. It is especially to be noted, however, that in the formula as reduced to the form shown above, the time (t) is independent of the rate of heating and is a function of the charge alone.

Description of the Apparatus.

The apparatus adopted for determining the temperature-conductivity is indicated in Figure 6. The cylinder, C, is of aluminum, a good conducting metal, unattacked by the explosives studied, 2 centimeters in internal diameter and 10 centimeters long. B is a stirred bath, which can be heated at a uniform rate. The arrangements already described were used for measuring thermo-elec-

[1] Walter P. White on the Melting Point Determination. Art. XLIV. Vol. XXVIII, American Journal of Science, Nov., 1909.

[2] Loc cit.

trically the temperature of the bath, of the cylinder, and of the center of the charge of test material within it. The cylinder was machined from a rod of aluminum and a hole drilled downward in the wall permitted the insertion of a thermo-couple, D, for determining the cylinder temperature. This thermo-couple was wrapped with a bit of tin-foil to make it fit the hole tightly. The temperature in the center of the charge is determined by a set of thermo-couples stretched along the axis as shown. A central wire of gold, G, .6 mm. in diameter, formed part of this thermo-electric circuit. The advantage of this arrangement is that temperatures are equalized along the wire so that the average temperature of the region covered by it is measured and not the accidental temperature at one spot as might be the case if fine thermo-couples alone were present. The thermo-couple wires were very fine, No. 30 for the constantan wire, with No. 36 for the copper wire. This thermo-couple system was suspended, as shown, from a light frame of glass rod, made as light as practicable, since glass is a better heat conductor than the materials investigated. The warming bath was vigorously stirred at a uniform rate by a mechanical stirrer and heated by a commercial electric resistance water heater whose heating power was regulated by a variable resistance rheostat.

The only new piece of apparatus requiring calibration was the multiple thermo-couple measuring the temperature of the center of the charge. This was calibrated at the fixed points on the temperature scale as shown, with the following results:

Temperature	E. M. F. (Microvolts) Standard	E. M. F. (Microvolts) Thermo-couple
0°	0	0
25°	989.1	967.0
50°	2034.3	2010.4

This large deviation is chiefly due to the fact that the original piece of constantan wire was not long enough to permit distant control operation and had to be spliced with a piece from another spool. A cause for difference is also due to the insertion of the gold wire in the circuit.

Outline of the Experimental Work.

The manipulation, which was conducted at a safe distance with a suitable barrier intervening, thus avoiding any danger of injury from explosion, is as follows:

(1) The stirred bath was started heating at a uniform rate of 2° per minute. This rate is controlled by observations of the bath temperature made at regular intervals by means of its thermo-couple, and by variation of the heating current through a suitable rheostat. Observations and regulations were made once in three minutes, leaving the other two minutes for observation of the temperature within the tested material.

(2) Observations of the cylinder temperature and the temperature at the axis of the charge were made at exact intervals.

(3) The significant observations were those which were made when the whole charge was warming at the same rate as the bath. A certain time was required for this rate to penetrate to the center and become constant. Thus it required from 18 to 20 minutes to heat the bath from about 10° to 50° when the maximum rate of heating, 2° per minute, was used. The uniform rate was reached when the center of the charge had the same rate as the containing cylinder. As soon as enough observations were made to show that the center of the charge and the cylinder were warming at the same rate and to establish what that rate was and what the difference of temperature between the two was, the experiment was finished. It was found that operations were facilitated by warming the bath very rapidly for about 5° at the outset, by using a low Bunsen flame. The steady heating rate in the charge was then reached at a slightly lower temperature.

The theory of the method neglects the heat lost or gained through the ends of the charge. In order to make this a negligible quantity, the end flow of heat was restricted by placing at the ends, both at top and bottom, very poor conductors, as follows: At the bottom, where some firmness was required to support the packing of the material, a piece of very porous brick, F, a combination of magnesia and asbestos mixed with water, and made more porous by adding a little baking powder at the time of mixing, was employed. At the top, fluffy asbestos, H, which was lightly packed around the merging wires, was used.

Since the apparent specific heat of most materials may on account of incipient melting increase enormously just below the melting point, the results obtained by melting and pouring in the charge during loading are likely to be misleading. For this reason, it was decided to keep well below melting point in getting the final results. In no case was the temperature of the charge allowed to run over 50°.

Hence the warming bath was started with ice water, so that the experiment could begin at 10° and end below 50°. For safety and uniformity it was decided to start all materials at the same low temperature. It was also found to be essential that the center of the charge be cooled nearly to the bath temperature before the experiment started. Since diffusivity depends upon conductivity and that in turn depends upon the state of mechanical aggregation, determinations were made at several different densities of loading to ascertain what effect this had upon the conductivity coefficient. As was anticipated, it was found that the conductivity coefficient varies inversely as the density of loading.

Example of an Experimental Determination

As in the case of determining specific heats, the detail figures for a typical determination (on TNT.) are given below, after which the final results of all the experiments are consolidated into a table with all necessary data to indicate the experimental conditions.

The following are the figures for one determination:

Time	Temperature of bath (Microvolts)	Temperature of cylinder wall (Microvolts)	Temperature of center of charge (Microvolts)
9.24		10	
9.25	77		128
9.26		110	
9.27			112.5
9.28	291	270	
9.29			194.5
9.30		430	
9.31	528		316.5
9.32		590	
9.33			458.5
9.34	767	735	
9.35			610
9.36		885	
9.37	969		746
9.38		1020	
9.39			886.5
9.40	1194	1170.5	
9.41			1022.5
9.42		1306	
9.43	1401		1168
9.44		1431.5	
9.45			1308
9.46	1605	1547	
9.47			1483.5
9.48		1592.5	
9.49	1800		1674

Four determinations similar to the above were made for each substance at the same density of loading which gave the following averages for the coefficients of conductivity and diffusivity at 25° C.:

Substance	Coef. of Conductivity (K)	Coef. of Diffusivity (h)	Density of loading (c)	Temperature
TNT.	0.00048	0.00197	0.64	25°
TNX.	0.00057	0.00225	"	"
Tetryl	0.00088	0.00338	"	"

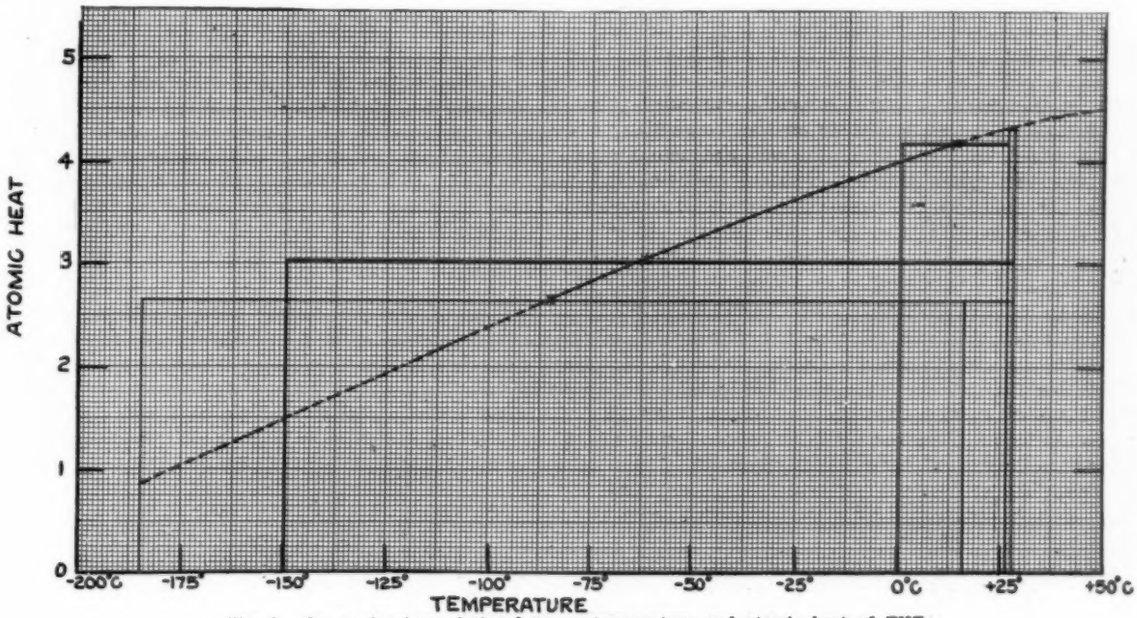


Fig. 8. Curve showing relation between temperature and atomic heat of TNT

In order to ascertain the relation between the coefficient of conductivity and density of loading, additional determinations were made with TNT. at higher densities, with results as follows:

Coef. of Conductivity (K)	Coef. of Diffusivity (h)	Density of Loading (c)	Temperature
0.00047	0.00150	0.783	25°C.
0.00045	0.00121	0.980	"

From the above data it is apparent, first, that the coefficients of conductivity of the three substances examined are in regular order of ascending molecular weights; and second, the coefficient of conductivity varies inversely as the first power, while the coefficient of diffusivity varies inversely as the square of the density of loading.

It is interesting to note that by extrapolating in the above table a value of .00038 is obtained at a density of loading of 1.62 which is the specific gravity of TNT. This density (1.62) represents the limit to which the density of loading can approach and it can be approximated only by extreme pressure (4,125 kg/cm²). When melted and cast the density of TNT. is between 1.57 and 1.60. Ordinary densities of loading vary between 1.50 for pressed and 1.60 for cast TNT. for which the value of 0.00039 for the coefficient of conductivity is approximately correct.

General Discussion

It is a matter of great interest to compare results with the determinations recently made by others in order to form some idea of the probable errors of each. Unfortunately few determinations of specific heat of explosive substances have been made and none are of record for the substances of this investigaation, notwithstanding their great importance and wide-spread use. This is probably due to the fact that explosive substances, because of their sensitiveness to heat, do not lend themselves to the methods of elevated temperatures usually employed in determining specific heats, so that investigators in this field, in choosing materials to work with, pass over explosive substances. Notwithstanding the absence of comparative data, however, certain conclusions and analogies may be drawn from an analytical study of our results.

Arranging our substances in order of ascending molecular weight, as follows:

Substance	M. W.	Sp. Ht.	Melt. Pt.
TNT	227	.2141	80.5°
TNX.	241	.2244	181.8°
Tetryl	287	.2405	129.5°

it is noted that, whereas the melting points are irregular, the specific heat is a regular function of the molecular weight. This is in accordance with the generalization that increasing atomic weight is accompanied by increasing atomic heat but in a lesser degree. Further analysis shows that the law of Kopp, that is to say, the molecular heat of the compound is equal to the sum of the atomic heats of the elements composing it, does not fully apply to our substances. This is illustrated by the following comparison:

Substance	Mol. Sp. Heat (Law of Kopp)	Mol. Sp. Heat (Observed)
TNT	.2806	.2141
TNX	.2909	.2244
Tetryl	.2860	.2405

Thus, calculations from the law of Kopp place TNT. and Tetryl very close together with TNX., the high member of the group, notwithstanding its intermediate molecular weight. However, there are several contributing reasons for this apparent deviation. In the first place in applying Kopp's law we have had to use values for the atomic heats of the elements C, H, N and O, at ordinary temperatures (+20° to +100° C.) as we could find no record for these values over the range of temperature used in our determination (—185° to +20° C.) with the single exception of C, for which Richards & Jackson[1] give a value of 0.0959. Marshall[2] gives the following values of these specific heats: C = 1.8;

1 Loc. cit.
2 Loc. cit. Vol. II, page 456.

H = 2.3; O = 4.0. No value is stated for N, which is known to depart widely from the law of Dulong & Petit. To supply this omission we calculated the value for N from the mean of several values given for air[1], as follows:

Swann	5.00
Joly	4.96
Regnault	4.86
Average	4.94

$$\text{At. Ht. of } N = \frac{4.94 \times 5 - 4.0}{4} = 5.2-$$

It is at once apparent that no conclusions can be drawn from values separated so widely on the temperature scale unless it is known that these values are sensibly constant over the range of temperature intervening. That this is not the case is strikingly shown by comparing Marshall's value (1.8) for the atomic heat of C at ordinary temperatures (+20° to +100° C.) with the value (1.15) calculated from the specific heat of C (at —188° to +20° C.) given by Richards & Jackson. Thus it is noted that C undergoes a very great variation in atomic heat with change of temperature. Assuming that Richards & Jackson's value for the specific heat of C is correct at the mean tmperature of his range, —84° C., the atomic heat of C is seen to decline 36 per cent in a fall of 104° C. This rate of decline, however, is not a straight line function but has been shown to be essentially parabolic, convex upward, and tending increasingly downward toward the absolute zero[2]. This being the case with C, it is safe to assume that the same is also true of H, N and O, since it is known that elements of low atomic weight vary greatly in atomic heat as the absolute zero is approached. If it be assumed that variation of atomic heat with temperature is approximately the same for H, N and O as for C, we should expect to find the difference between our observed specific heats and those above calculated according to the law of Kopp to be approximately 36 per cent. These differences are, however, seen to be as follows:

	Per cent
TNT.	23.7
TNX.	22.6
Tetryl	14.7

This brings us to the second general cause for deviation from Kopp's law, namely, the atomic heats of the elements (specially gases) in a free state are widely different in a combined state. This is particularly true at the lower temperatures. This phenomenon is more or less adequately accounted for by Planck's Quantum Theory from which it is possible to calculate from the spectrum of a gas the variation of the specific heat with temperature. White[3] has shown that the atomic heat of oxygen in combination is abnormally low at room temperature. In this connection it is interesting to note that the deviation of our substances from Kopp's law is proportional to the percentage of combined oxygen present in the compound. Thus tetryl, which exhibits the greatest deviation and irregularity, contains the greatest percentage of oxygen. Our conclusion in this matter is, therefore, that the subject cannot be adequately handled without taking into account those variations of specific heat which have been correlated with the quantum hypothesis. This would lead us far afield and quite beyond the scope of the present investigation.

For purposes of practical application it is desirable to know the value of the specific heats of explosives within the range of temperature at which they are ordinarily employed; that is, say from +20° to +50°. Unfortunately the determination of specific heats of many explosives at these temperatures would be not only dangerous but probably misleading, since it has been found that as the melting points of many of the more important explosives are approached variable and confusing specific heat results are obtained to which little confidence can be attached.

Being thus limited to a range of temperature from ordinary room temperature (+20° C.) to a point well below the melting region (+50° to +60° C.) affords us but a very narrow bracket some 30 to 40 degrees. As this limited working range is only from one-fifth to one-sixth that used in our determination it demands that temperature measurements be taken with several times the accuracy required in our work for the same results. Such refinement is quite beyond the possibilities of our apparatus and probably beyond anything but the most precise work such as described by White[4]. In order to obtain an approximate value for the specific heats of our substances at ordinary temperatures the following procedure was resorted to:

For TNT., the least sensitive of our substances, a value was obtained for its specific heat from 0° to +25° C. and a value for an intermediate range (from —150° C. to +25° C.). See experiments Nos. 13 and 14 in table above. These various values were then plotted in the manner shown in diagram (Fig. 8). Atomic heats are plotted as ordinates and temperatures as abscissae. Areas represent quantities of heat and depict the data actually observed. The curve shows the most probable values for the specific heat at each temperature, the curve being drawn so that it cuts off between any two ordinates the same area as the corresponding rectangle. It is noted that the curve is convex upwards and exhibits the same tendency as almost all of the substances thus far investigated.

From the curve thus constructed we establish the specific heat of TNT. at ordinary temperatures (—200° to +50°) within a reasonable degree of accuracy, as 0.3776.

It was planned to construct similar curves for TNX. and Tetryl, but time would not permit. At the same time it is believed that since TNT., TNX and Tetryl are all nitro-aromatic compounds of such closely similar structure, their curves would be sensibly parallel throughout the range plotted, and in the absence of better data and for the purpose of calculating their diffusivities, we can compute the specific heats of TNX. and Tetryl from our observed data and the characteristics of the TNT. curve. As thus computed we establish the values for the specific heats of TNX. and Tetryl at ordinary temperatures (+20° to +50° C.) at 0.3950 and 0.4233 respectively.

Clearly such results are not absolutely accurate and the subject is one that will well repay further research. The determinations made here are but a sketch suggesting in broad lines the form of further work. Preliminary and tentative as our figures undoubtedly are, they constitute an invasion of a field practically hitherto untouched and furnish a point of departure for the ultimate determination of the interesting and important physical data with which they deal.

1 Loc. cit. Vol. II, page 455.
2 See pp. 21-23 of "Silicate Specific Heats," Second Series, by W. P. White, Amer. Jour. of Science, Vol. XLVII, Jan., 1919.
3 Loc. cit.
4 Calorimetric Methods of High Precision, page 2313, et seq., Jour. Amer. Chem. Soc., 1914.

(The End)

The Ordnance Financial Cycle

By

COLIN E. McRAE

BECAUSE few of those who observe the workings of the Ordnance Department in peace and war actually understand the methods by which funds are obtained and expended, I believe that a brief discussion here of the various steps in the process may be timely. The readers of ARMY ORDNANCE will be interested in such a topic, because there are few among them who in one way or another during the World War have not come into actual contact with the financial functions of the Department. Likewise, it may be that there are many among the Ordnance Officers' Reserve Corps to whom this subject may be of increasing importance because, in time of war, they may be called upon to administer some phase of the process.

Major C. E. McRae

Estimates

Before any expenditure of public money can be made it is necessary to have Congress appropriate funds which are based on estimates submitted for the purposes desired. The estimates transmitted to Congress may be divided into three classes: (a) The Budget, (b) Supplemental, (c) Deficieney.

On or before September 15th of each year the heads of the various executive departments, and other offices authorized or required to make estimates, submit to the Director of the Budget their annual estimates for the public service. Upon receipt of these estimates by the Director of the Budget it is the duty of his office to have compiled "The Budget," which is transmitted to the Congress by the President on the first day of each regular session. This Budget, therefore, contains for the War Department an outline of its various activities, such as the Adjutant General's Office, the Ordnance Department, etc., with an estimate of funds required by these Departments to carry out the projects contemplated during the ensuing fiscal year. A supplemental estimate is required in cases where Congress has enacted certain laws creating new requirements subsequent to the presentation of the annual estimates, and does not authorize payments from funds previously appropriated. A deficieney estimate is usually required when, due to unforeseen conditions, the expenditure of money during the fiscal year indicates that the amount appropriated will not be sufficient. The Revised Statutes of the United States provide that "No executive department or other government establishment of the United States shall expend in any one fiscal year any sum in excess of the appropriations made by Congress for that fiscal year, or involve the government in any contract, or other obligation, for the future payment of money in excess of such appropriations unless such contract, or obligation, is authorized by law." When such obligations are authorized and incurred deficiency estimates are necessary.

The estimates for the Ordnance Department are prepared from those received from the various Ordnance establishments, which are consolidated by the Fiscal Division for the Chief of Ordnance and are submitted to the Secretary of War through the Budget Officer for the War Department. These estimates are supported by notes itemizing the various projects which it is contemplated will be inaugurated during the year for which the estimates are prepared. In addition to being supported by notes, the estimates are defended before Congress by officers designated by the Chief of the Bureau for this purpose.

Appropriations

An appropriation bill having passed Congress is sent to the President for approval and signature, after which it becomes a law. From the President it is sent to the State Department for record and assignment of "Public No.", and a certified copy is furnished to the Secretary of the Treasury. The latter sends that copy to his Bookkeeping and Warrant Division where the appropriations are recorded under their proper titles. The Secretary of War is then notified that there is a certain amount of money in the Treasury, subject to his requisition. The Chief of Finance, who is charged by law with the disbursement of the funds for the War Department, and such other fiscal and accounting duties as may be required by law or assigned to him by the Secretary of War, is the Requisition Officer of the Secretary of War.

Under the provisions of Section 3679 R. S., as amended by the Act of Congress approved February 27, 1906 (34 Stat., 48 and 49), the various annual and biennial appropriations made for the services of the Ordnance Department are, on or before the beginning of each fiscal year, apportioned by the Secretary of War, so as to prevent undue expenditures in one portion of the year that might result in deficiency or additional appropriations for the remainder of the year. This apportionment constitutes the first grand division of the appropriations concerned and simply limits under the several appropriations the amounts which may be expended during a designated period, this apportionment, at the present time,

being by quarters of the fiscal year. Unless otherwise stated, appropriations are made to cover a fiscal year (which begins July 1 and ends June 30) subdivided as follows:

First Quarter—July 1 to September 30,
Second Quarter—October 1 to December 31,
Third Quarter—January 1 to March 31,
Fourth Quarter—April 1 to June 30.

Based upon these apportionments, the Fiscal Officer, who has general charge of the apportionment and subapportionment of funds in the Ordnance Office, makes further subdivisions, assigning to each of the several Divisions of the Office the amounts which will be applied to the duties of that Division. After the subapportionments are made to the Divisions of the Office the actual distribution of funds, in order to carry out the purposes for which the appropriations were made, is affected by the process of allotting for each specific object a definite amount on the books of the Ordnance Office in the Finance Contact Section. These allotments are then routed to the Office of the Chief of Finance for proper record. The Finance Contact Section, besides keeping a record of allotments and apportionments, acts as liaison on all finance matters with the Chief of Finance, the several Bureaus of the War Department, and other government agencies. Allotments are issued to the various agencies as, what are called, "Procurement Authorities." When an officer at an Ordnance station has been notified of an allotment of funds for any purpose he is authorized to make such disposition, and to incur such indebtedness in the amount allotted and in accordance with existing orders, as may be necessary for carrying out the object for which the allotment was made. Records are kept at Ordnance stations of all transactions under allotments, stock fund, and shop expense accounts on forms prepared for this purpose. An obligation must not be incurred where there is no allotment to authorize it, or when the allotment does not properly authorize it. An appropriation is properly charged with all expenditures necessary to accomplish the object for which it was made, unless particular items of expense are specifically provided for in some other appropriation (IV Comp. Dec. 24). Therefore when a specific appropriation is made to cover particular expenditures such expenditures cannot be charged to a general appropriation which might otherwise be applicable. Whenever an allotment is found to be insufficient, timely report is made in order that an additional allotment may be made, or that the work to be done may be modified. Should the allotment be in excess of that required for the work the surplus is reported to the Ordnance Office for revocation. Unless specifically authorized, no advance of public money may be made prior to the receipt of supplies or services for which payment is made, with certain exceptions to this general rule, viz., the payment of subscriptions to newspapers, periodicals and other publications purchased from public funds for official use, which may be paid in advance from appropriations available at the time of making subscriptions.

The appropriations of the Ordnance Department may be annual, biennial and permanent. Annual and biennial appropriations are available for obligations made in the Office of the Chief of Ordnance during the fiscal year, or years, for which appropriated and for disbursement two years after they expire for such obligations, as, for example, the appropriation "Ordnance Service, 1923," an annual appropriation, is available for current obligations during the period July 1, 1922, to June 30, 1923, inclusive, and for expenditures on such obligations two years thereafter. The appropriation "Ordnance Stores—Ammunition, 1923 & 1924," a biennial appropriation, is available for obligations for the period July 1, 1922, to June 30, 1924, inclusive, and for disbursements on such obligations two years thereafter, at which time all unexpended balances revert to the Treasury. Permanent appropriations are available for disbursement until expended. The titles and objects of the appropriations of the Ordnance Department are published annually in Ordnance Office general orders soon after the approval of the appropriation bills. The title of an annual or biennial appropriation is always followed by the designation of the year, or years, for which the appropriation is made; the title of a permanent appropriation is not followed by the designation of any year.

As all unexpended balances of annual and biennial appropriations are required by law to be covered into the surplus fund of the Treasury at the expiration of two years after the close of the fiscal year, or years, for which made, such balances are not retained beyond that period, as no disbursements can be made from the appropriations after that date.

The Army Act of June 5, 1920, which reads, in part, as follows:

"That all orders or contracts for the manufacture of material pertaining to approved projects heretofore or hereafter placed with Government-owned establishments shall be considered as obligations in the same manner as provided for similar orders placed with commercial manufacturers, and the appropriations shall remain available for the payment of the obligations so created as in the case of contracts or orders with commercial manufacturers," provides that government establishments may place orders for material against such approved projects as may be necessary for their completion during the full life of the appropriation, and also make payments, during the same period, for the necessary labor in connection with the approved project; provided payment can be made prior to the time the funds revert to the Treasury Department by limitation. This provision of law was requested at the time permanent appropriations were discontinued, in order to enable the Ordnance establishments to complete orders for manufacture, or for definitely defined experimental work, during the life of annual and biennial appropriations. With appropriations for current expenses, such as "Ordnance Service" and "Repairs of Arsenals," it has not been the policy of the Department to issue approved projects, except in some special cases, or for current work which should be completed within the current fiscal year.

Army Account of Advances

Under authority contained in the Act of Congress approved June 5, 1920, deposits to the official credit of disbursing officers will thereafter be made under "Army Account of Advances" instead of by appropriations as heretofore. This method simplifies the accounting work of the disbursing officer and is a great aid to the efficient and expeditious settlement of Government accounts. The Act provides:

"That the Secretary of War be, and he hereby is, authorized to issue his requisitions for advances to disbursing officers and agents of the Army, under an "Army Account of Advances," not to exceed the total appropriation for the Army, the amount so advanced to be

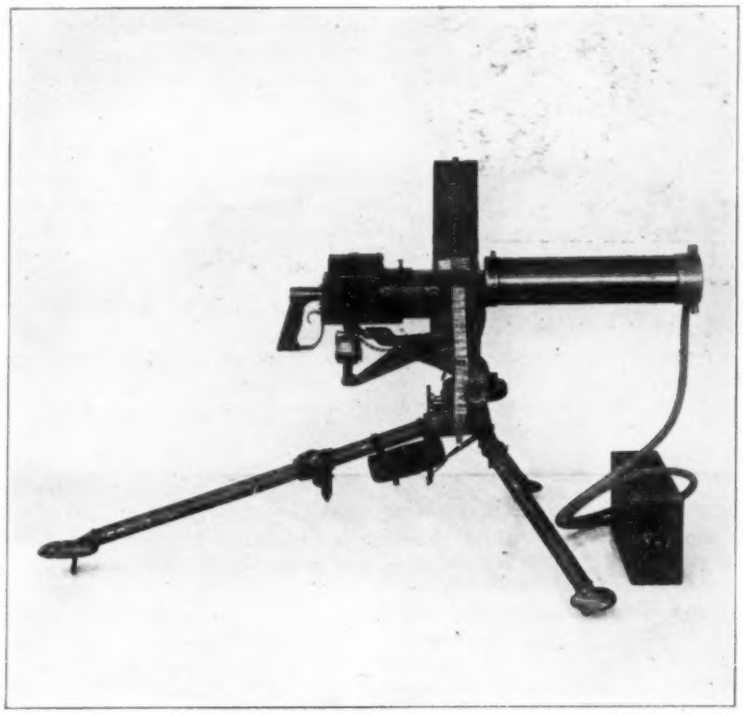
(Continued on page 266)

New Designs for the Next War

By

JAMES L. HATCHER

A CONSIDERABLE problem is presented to the Ordnance Department in time of peace to make changes in equipment and to eliminate defects made apparent during extensive use of material in war, and thereby establish for the next intensive production period an approved and satisfactory design. Constant efforts are made and a great deal of work is done to perfect and standardize each item of Ordnance. New experimental models are constantly being made and tested with the view of finding something superior to that which is now considered standard.



Idealized Browning Machine Gun

In 1916, at the time of the Border trouble, the small arms equipment of the Army was very limited. The World War came on and a tremendous production basis was established for supplying troops at a rate of mobilization which exceeded any estimate of preparedness. It was necessary at that time to adopt many new items of small arms equipment, especially machine guns. In many instances there was nothing to do but to delay production until a suitable design for a particular need could be found where nothing before existed. This condition caused nearly every item of equipment to be rushed into production before a suitable trial and proper check of its efficiency could be made. Therefore, there have been since the war and are now many defects which became apparent while establishing production and while in the hands of troops in France and in this country. It is now the problem of the Ordnance Department either to correct these defects in existing material, or if that is not possible, to change the manufacturing drawings so that another emergency will find approved, and as far as possible, standardized designs ready for immediate production with the least delay.

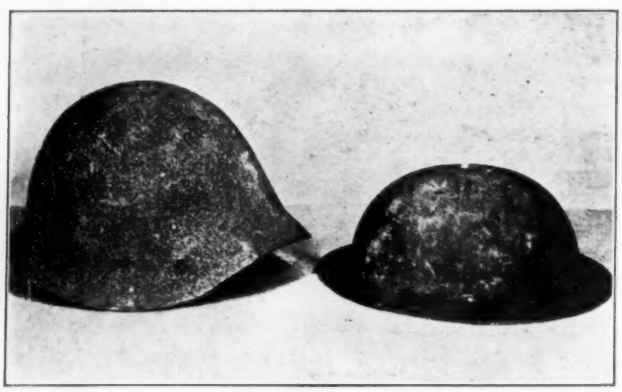
Now, when everyone is turning toward a lasting peace, it is particularly hard to make changes, and often the only possible action which can be taken is to provide for correction, in future manufacture, of bad features in present equipment. Troops in the field, therefore, must continue to use some equipment in which there are known defects. Only in the event of a war of major proportion would new production be sufficiently large to take care of that feature.

The service at large, which of course is most intimately concerned in the weapons supplied to it, is naturally the source of many complaints and suggested changes. While the Ordnance Department is seriously handicapped in properly caring for such suggestions, the greatest pains are taken to convince the using services that every effort is being made to give them the best possible equipment and that full recognition is given their criticisms and ideas for improvements, since they come from the fundamental source. In order to carry out the policy of full cooperation with the line of the army to supply it with material with which to make tests for its own information and for that of the Ordnance Department, a system of experimental work was established during the war and has been continued up to the present time. It is of the utmost importance in order to keep the Department in close touch with the needs of the line so that adequate and proper equipment can be supplied.

At the manufacturing arsenals which are maintained during peace time, there are design and experimental units whose functions are to make and test new equipment and make changes in present equipment. Experimental samples are first tested by the experimental units and then sent to the service at large for test.

The importance of the experimental units cannot be exaggerated. If the Army is to keep abreast of the progress of equipment in foreign armies and adequate preparation is to be made to cope with the modern weapons of the enemy, it is imperative that new types of equipment must be manufactured and tested to determine their useful qualities. Designs of experimental equipment are first made, then carefully considered by the Technical Staff and the Manufacturing Service of the Ordnance Department. They are then submitted to the consideration of the branch of the Army concerned. If approved, a sample is manufactured and again considered in the same places,

tested if necessary, and if more than one sample is required, additional work on the project is completed. The material is then submitted to an ordnance test before being sent to the using service for final trial. After being tested in the field, the Ordnance Department is informed of its value and of the necessary changes. In many cases, this results in new models being made. When the experimental models are approved, if at all, certain quantities may be manufactured immediately within the limit of the funds available for issue to troops. If this desirable action can not be taken, the design is at least standardized, official



Trend of helmet design—the flat British type is being displaced by the style shown on the left

drawings are completed and filed for future manufacture, when large production is necessary and possible.

When an emergency arises and production on an extensive scale must be started immediately, there is no time to do any experimental work or consider changes in design. To do so means but one thing, the manufacture of standard equipment is discontinued awaiting the completion of the design under consideration before it can be started into production, with the result that facilities are tied up, production is delayed and the particular equipment perhaps not supplied to the troops in time for it to be effective.

It has been advocated by good authority that upon declaration of war, changes in design and improvements in equipment should be prohibited altogether and the war won or lost with types of weapons and material in existence at its beginning. There would have to be exceptions to such a policy naturally because new weapons are born of the conditions under which an army is fighting. Those conditions are always different and seldom can be accurately anticipated. The gas mask, trench mortar, the Livens projector and similar weapons which were little known, if at all, until 1914, are now standard equipment. When the late war resolved itself largely into a matter of position fighting the new weapons incident thereto were of course in demand and had to be supplied.

When the necessity for a new type of equipment is seen every effort is made to obtain the best that is possible. The Ordnance Department calls on the most skilled engineering talent in the country for the production of proposed new weapons and offers every encouragement for their advancement. As an example, there is recognized at the present time the need for a suitable type of semi-automatic rifle. Specifications covering the requirements for such a rifle are published for commercial arms concerns and inventors at large, and the best known arms designers are particularly informed of the needs of the Army in this respect and are urged to submit experimental rifles for test.

The Ordnance Department keeps in close touch and cooperates whole-heartedly with the most skilled arms and ammunition manufacturers in the country. Information is exchanged with them and samples of standard equipment are made available for their use in promoting better designs.

In order that proper information may be obtained and that the best designs may be originated, there are maintained in the Ordnance Office and at the manufacturing arsenals, museums of standard, experimental and foreign arms and ammunition, so that reference can be had to them at any time by those engaged in design and manufacturing work, and in this manner the Department is kept fully informed of all types of modern weapons in use. Commercial arms are also obtained and carefully examined for information with reference to the principles involved in them.

It is the aim of the Ordnance Department to obtain equipment which will not need to be changed immediately upon declaration of war and to predict as accurately as possible the conditions of the next war and anticipate them now.

Personals

General John H. Rice, U. S. A., retired, who served with distinction in the Ordnance Department for more than thirty years, has recently become associated with the E. I. duPont de Nemours Company in a consultant capacity. General Rice was Chief Ordnance Officer of the American Expeditionary Forces in France at the time of the Armistice. He was serving as Chief of the Manufacturing Service in the Office of the Chief of Ordnance at the time of his retirement in 1920.

General Rice is sailing for France on the steamship *Paris*, leaving New York February 6, 1924, for the purpose of taking up some special work for the duPont Company.

A meeting and dinner of the Division heads of the New York District Ordnance Office was held on January 18 for the purpose of discussing District Office organization. The Reserve Officers assigned to the New York District held a banquet in that city on January 22.

Oscar H. Fogg after January 1, 1924, will be President and General Manager of the Baltimore Gas Appliance and Manufacturing Company, Bayard and Hamburg Streets, Baltimore, Maryland.

The California Post of the Army Ordnance Association was established during December, 1923. The headquarters of the Post are at 58 Sutter Street. Officers will be elected shortly. That a realization of the importance of adequate ordnance development exists in the minds of public-spirited citizens is evident from the interest being shown in local posts of the Association in all sections of the country.

A. L. Jenkins, the Brookline Apartments, 3545 Biddle Street, Clifton, Cincinnati, Ohio, was appointed Major in the Ordnance Officers Reserve Corps, effective December 5, 1923.

Mr. W. R. Swint of the Chemical Division, Explosives Department, E. I. duPont de Nemours Co., Wilmington, Delaware, has been made assistant manager of the European office of the same company with headquarters in London. His new address is Capel House, 54 New Broad Street, London, E. C. 2, England.

Transport Wagons for Medium and Heavy Field Artillery

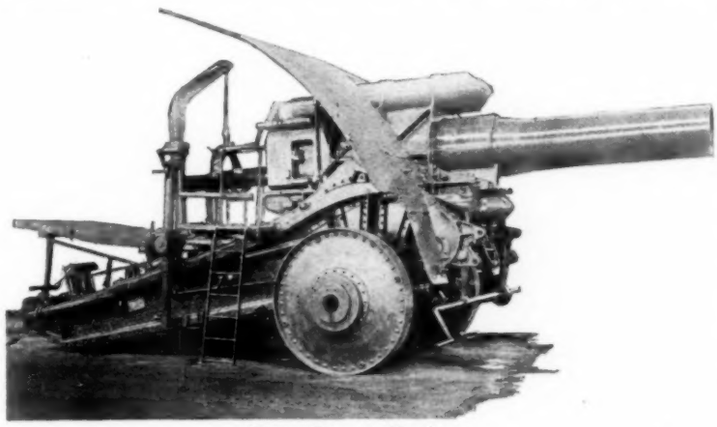
PART III

By

T. A. CONLON

THE 420-mm. Howitzer Carriage Transport Wagon (German) is the heavy matériel used so successfully by the Germans during the war.

The battery consists of two pieces; each piece with its carriage and erecting mechanism is transported on five transport wagons with steel chassis and metal wheels. Each wagon is a special model appropriate to its function and is hauled by a tractor. In addition, four powerful automobile trucks accompany the battery and carry various supplies and accessories. Although the weight of the wagons vary slightly the average is approximately 15 tons.



42-cm. German Howitzer

The wagons of each piece are numbered and designated as follows:

No. 1, The Appliance Wagon. This vehicle carries the material required in assembling and dismounting the howitzer and carriage. The principle item of the load is the erecting frame;

No. 2, The Platform Wagon. This carries the "U"-shaped one piece steel platform with two-box girder steel racks for hauling the carriage wagon into place on the platform;

No. 3, The Cradle and Spade Wagon. This piece carries the howitzer cradle and a huge spade of special construction;

No. 4, The Carriage or Trail Wagon which is the carriage proper of the piece, the hind wheels of the wagon constituting the carriage wheels as on a field carriage; the front wheels of the wagon are used only for transport and are removed before the piece is mounted; and

No. 5, The Howitzer Wagon which carries the piece.

The tractor attached to wagon No. 1 is larger and more powerful than the others, being approximately 80 horsepower, and is provided with a steel cable and drum slung under the chassis. This drum is driven by the engine and is used for the purpose of hauling the different wagons on and off the platform. The tractors attached to wagons Nos. 2, 3, 4 and 5 have engines of approximately 50 horsepower.

The position of the emplacement having been determined, the column is moved in its proper order, No. 1 wagon leading. No. 1 wagon is hauled to the emplacement and after erecting the frame and unloading the other accessories is hauled aside. The motor tractor of No. 1 wagon then takes up a convenient position a short distance in front of the emplacement from which it can haul the remaining wagons on to the platform, by means of the cable drum. If the ground does not permit of a straight line pull the tractors are located at any convenient point and the cable led around a snatch block fastened to an anchor. A 420-mm. battery commander stated that a battery could be set up for firing in 3 hours under favorable conditions. The personnel of the battery consists of 280 men commanded by a captain. Two hundred of the men are artillerymen, the remainder being chauffeurs and mechanics. In actual firing, 25 men are required at each piece.

240-mm. Gun Carriage (48 cal.), Transport Wagons (German)

The weight of this carriage in firing position is 123,200 pounds with a muzzle energy of 6,625 metric tons. The weight of the gun complete is 36,000 pounds. The carriage is mounted on outriggers and a cross-shaped platform. The field of traverse is 360 degrees.

The vehicles are without support or rubber tires. Caterpillar bands are provided for the wheels and carried in the store wagon when not used. Draft is exclusively by tractor capable of hauling loads of 24 tons.

The order which the vehicles must occupy in the marching column, and in which they are required on going into action is:

No. 1, Store Wagon, carrying small stores and caterpillar bands for wheels;

No. 2, Platform Wagon I, carrying lifting devices and platform;

No. 3, Platform Wagon II, carrying inclined rails and outrigger with pivot;

No. 4, Carriage Wagon, carrying carriage and cradle; and,

No. 5, Gun Wagon, carrying complete gun.

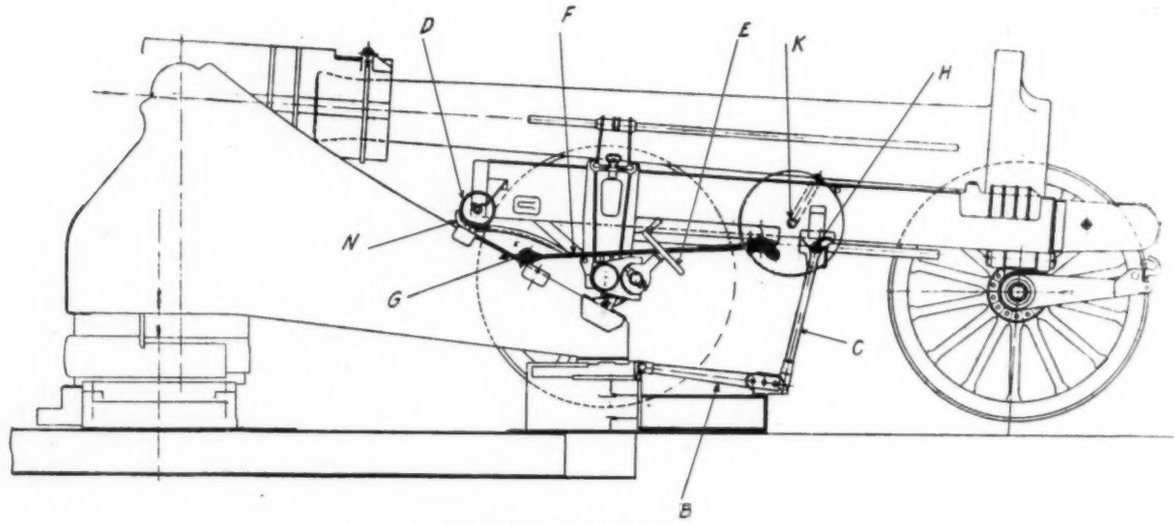
The procedure for erecting the gun is as follows:

A cross-shaped excavation having been prepared to receive the platform, the lifting device is unloaded from wagon No. 2 and erected on rails in a very simple manner. By means of the lifting device, the platform is then unloaded from wagon No. 2 and assembled in the excavation, after which the outrigger is unloaded from wagon No. 3 and connected with the platform.

With the aid of the inclined rails the carriage wagon (No. 4) is brought into position over the emplacement, and the carriage set down on the platform. The inclined rails are further employed to bring the gun wagon (No. 5) into the position for transferring the gun to the carriage.

To assemble the carriage body, back the carriage body over the bed until it is approximately in line. Place the screw jacks under the front end and take the load off the rear wheels. Remove the rear wheels, unlock the lifting screws in the front axle and then lower the carriage by means of the screws and jacks.

The Howitzer transport wagon, like the other two, is without spring supports or rubber tires. The wagon body is built up of sheet metal and contains an endless chain running over sprockets at either end of the wagon. The chain is attached to the breech by a special link and is used for loading and unloading the wagon. The chain is driven by a train of gears, actuated by two or more men working cranks on either side of the wagon. Under the wagon body is a traversing and lifting gear for maneuvering the body into position.



British Howitzer Top Wagon

The latter operations necessitate the employment of a rope winch carried on the tractor.

British Transport Wagons

The transport wagons for the Vickers 9.2-inch howitzer carriage, Mark I and Mark II, differ somewhat from those used by the Germans and French, with the exception of the howitzer transport wagon which is similar to the German.

The platform transport wagon takes up its load by means of lifting screws in the axles while the top carriage wagon takes up its load with two lifting screws in the front axle and two screw jacks applied under the top carriage near the rear axle.

The weight of the assembled service mount is 35,500 pounds.

Weights of the Mark II transport wagons loaded are:

Platform transport wagon	12,500 lbs.
Top carriage transport wagon	14,500 lbs.
Howitzer transport wagon	14,600 lbs.

To assemble the 9.2-inch howitzer carriage, first excavate for the steel firing beams and lay them flush with the ground. Place the wagon wheel guide rails in position and locate the axle stop for the platform transporting wagon.

To assemble the platform, back the platform wagon into position over the firing beams. Lower the platform onto the beams by means of the screws in the axles. Secure the bed to the beams. Remove the axle and wheels.

To assemble the howitzer in the carriage cradle, the transporting wagon is backed into position so that the guide rollers D are approximately in line with the ramps N on the carriage body, and the strut C in line with the thrust bar B, working, if necessary, both traversing gear on the carriage bed and gear E on the wagon.

Place the winch on the spindle H, turn the crank to slack the cable F, secure cable to the carriage body by the pins G and turn the crank in the reverse direction—noting that strut C rests upon the thrust bar B as soon as practicable. Again turn the crank until the wagon is raised from the ground and is in its extreme forward position.

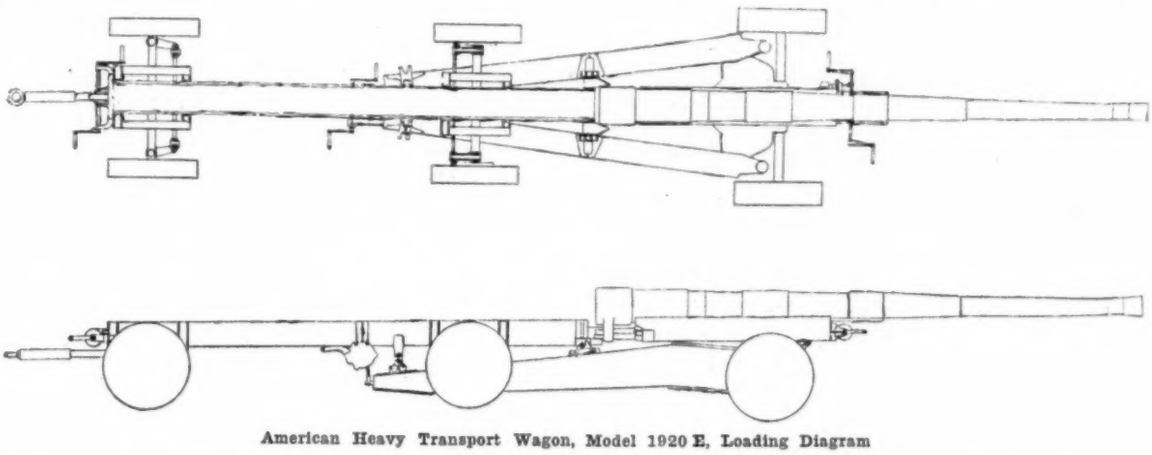
Elevate the cradle until in line with the howitzer, then place the crank on the spindle K and haul the howitzer along until the keys enter the keyways.

American Transport Wagons for Medium and Heavy Field Artillery

Previous to the World War, the Ordnance Department built a 7.6-inch howitzer carriage, Model E, and a 12-inch howitzer carriage, Model E, both of which were provided with transport wagons. The first carriage broke up into two loads for travel and the second carriage into 3 loads. As these vehicles were not sufficiently developed when the war came on they were not put into production, and since the war they have been abandoned as they did not meet the specifications laid down by the Caliber Board.

Since the war, the medium-heavy transport wagons have

been designed. The Medium Transport Wagon, Model 1920, is built to take the 4.7-inch gun and the 155-mm. howitzer, Model of 1920E. The heavy transport wagon is built to take the 155-mm. gun and the 8-inch howitzer,



American Heavy Transport Wagon, Model 1920 E, Loading Diagram

Model of 1920E. These vehicles are rubber tired and spring supported.

To adapt the wagon to the gun or howitzer carriage it is only necessary to use the proper ramps on the trail, as there is but a slight difference between the height of the gun and the height of the howitzer slides. To mount the piece on the service carriage, the rear wheels of the wagon are run over the trail until the guide brackets on the wagon engage the ramps on the trail. The windlass cable on the wagon engages the end of the trail, and the trail is lifted until the rear wheels of the wagon are off the ground, and the gunslides on the two vehicles come into the same plane. The trail is then locked to the wagon.

The front end of the cradle and the front end of the wagon are fashioned to receive a windlass.

When transferring the piece to the service carriage, the windlass is on the front end of the cradle; a cable is fastened to the recoil rod lug on the gun, and the free end is passed two or three times around the windlass. As the gun is hauled on the cradle, the free end of the cable coils on the ground. To load the wagon, the windlass is moved to its seat on the front of the wagon, and the rope attached to the gun lug.

These vehicles are now at Aberdeen Proving Ground where they are undergoing road and field test.

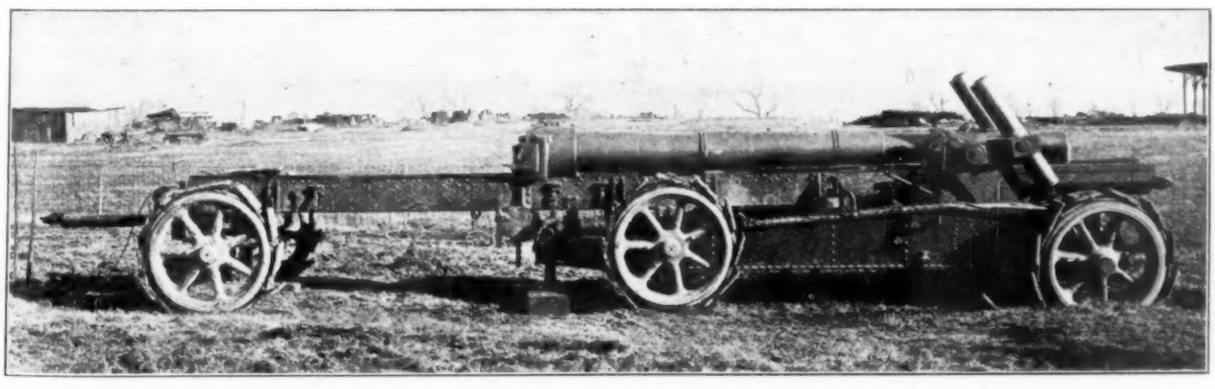
Since arriving at the Proving Ground the heavy transport wagon has been road-tested 500 miles and has been given a maneuvering test of transferring the gun and howitzer to and from the carriage.

The road test consisted of hauling the loaded wagon over hard roads and across fields, the results were satisfactory until the wagon was caught in swampy ground where it was stalled over night. During the night the wheels were frozen and required the combined effort of a 10-ton tractor and the 8-inch howitzer motor carriage to free it. The rear springs were broken.

The transfer tests have not been entirely satisfactory. The body is supported at four points and when the front wheels of the wagon are not resting on the same plane as the carriage wheels, the body of the wagon is distorted so that the cannon does not slide readily. Recent tests have indicated that jacks under the trails can be utilized to eliminate the distortion sufficiently to accomplish the transfer operations satisfactorily.

Conclusion

In the selection of a transport wagon, the type will depend largely upon the gun carriage or mount that the wagons are to serve. The French type of vehicle, consisting principally of a front and rear axle unit, appears to possess a maximum of simplicity. These vehicles strongly recommend themselves from the point of manufacture. But there is a greater element of risk in transferring the piece on and off vehicles of this type; and,



8-inch Howitzer being Retracted from Carriage to Heavy Transport Wagon on Rough Ground

The weight of the medium wagon, empty, is__ 3,500 lbs.
The weight of the medium wagon, loaded, is__ 7,700 lbs.
The weight of the heavy wagon, empty, is____ 6,700 lbs.
The weight of the heavy wagon, loaded, is___ 15,700 lbs.

whereas the German vehicles are more costly, they perhaps make up for the difference in the larger factor of safety secured by the more permanent relation between the transport wagon and the service carriage.

In comparing the British 9.2-inch howitzer wagons with the Schneider and the German 240-mm. howitzer wagons, it will be noticed that the latter require the assistance of an elaborate frame-work and lifting mechanism to set their platfrom and top carriage in place; whereas the British 9.2-inch platform and top carriage transport wagons place their load in position with the assistance of the two screw jacks and the lifting screws in the axles. Some of the difference might be explained by the greater muzzle energy of the French and German matériel, and the difference of platform design which makes the French and German mounts more stable than the British mount when firing.

Very little can be said of the American-made transport wagon, as there are none in service with the Army, and the new experimental medium and heavy transport wagons have not been given a sufficient test to prove their desirability under service conditions.

When it is considered that the new caterpillar tractors have a ground pressure of approximately 8 pounds per square inch, and that the new pontoon bridges for infantry divisions, corps, and army matériel specify a maximum load of 15,000 pounds under each axle, or 30,000 pounds under two axles spaced 13 feet apart, it will be seen that the heavy mobile artillery will not be free to march far from the improved highways except under very favorable conditions.

The transport wagon makes possible very powerful mobile field artillery as it permits the siege carriage to be broken up into loads that are practicable and in the case of such matériel as the U. S. 8-inch howitzer carriage, Model of 1920E, it permits of the use of a 15-ton tractor, a vehicle more practicable for general use than a 20-ton tractor, which would otherwise be required.

[EDITOR'S NOTE: This article concludes the series by Mr. Conlon on "Transport Wagons for Medium and Heavy Field Artillery." Part I of the series was published in the January-February, 1923, number of ARMY ORDNANCE, Vol. III, No. 16. Part II appeared in the July-August, 1923, number, Vol. III, No. 19.]

Meeting of the Ordnance Division A. S. M. E.

An interesting and valuable meeting of the Ordnance Section of the American Society of Mechanical Engineers was held in the Engineering Building, New York City, on December 5, 1923.

Mr. Fred J. Miller, the Chairman of the Section, and a Past-President of the A. S. M. E., presided. A paper on "New Instruments for Physical Measurements" was presented by Colonel Wm. H. Tschappat, Ord. Dept., Commanding Officer of the Aberdeen Proving Ground, and one by Captain H. W. Churchill, Ord. Dept., Executive Assistant to the Chief of the New York Ordnance District on "Some Production Problems in the War Departments Procurement Program."

Col. Tschappat's paper described work being done with a number of instruments used in making physical measurements at the Aberdeen Proving Ground such as the star gauge, Boulengé, Aberdeen and Solenoid chronographs, Piezoelectric gage, etc. As this paper was reprinted in *Mechanical Engineering* for December, 1923, it is not abstracted here.

Captain Churchill's paper pointed out that for the first time in its history our country has a definite military policy, established by the National Defense Act of June 4, 1920, in contrast to the policy of drift which controlled our destiny for nearly a century and a half and which has cost us the loss of hundreds of thousands of lives and many millions of dollars. He described the steps which are being taken to insure an adequate and uninterrupted flow of munitions to our troops in time of war and showed that the measures being adopted have many advantages to the country's industry as well as to the War Department. Among the problems which Captain Churchill mentioned as urgent at the present time were—

The selection of reserve officer personnel for procurement work,

The securing of facilities for manufacturing war material,

Standardized war contracts,

Industrial exemption from military service,

The supply of raw materials,

The gage question.

The paper brought out a very interesting discussion which was participated in by General C. L'H. Ruggles, Chief of Manufacture, Office of the Chief of Ordnance; Mr. Buttenheim, Vice-President of the McKiernan, Terry Dutt Co.; Mr. Otto Bert, Superintendent of the Nathan Manufacturing Co.; Mr. M. S. Cumner, Vice-President of the Nestor Manufacturing Co.; Colonel Alten S. Miller, Vice-President of the Bartlett-Hayward Co.; Mr. Luther D. Burlingame of the Brown & Sharpe Manufacturing Co.; Mr. C. K. Decherd, Master Mechanic, The International Silver Co.; Mr. C. J. McPherson, the J. G. Brill Company; Mr. George B. Warner, Secretary, The C. H. Cowdrey Machine Works; Mr. W. S. McIntosh of the S. A. Woods Machine Co.; Colonel B. H. Blood, General Manager of the Pratt & Whitney Works of the Niles-Bement Pond Co.; Mr. J. G. Worker of the American Engineering Co.; Mr. R. K. Blanchard, Assistant Secretary and Engineer of the Neptune Meter Co.; Mr. J. C. Mattern, the Singer Manufacturing Co.; Mr. George Barth, President of The Bigelow Brush Co.; Mr. F. E. Swope, Jr., of the American Metal Works; Mr. J. R. Byrne, General Superintendent, The Poole Engineering Co.; Mr. C. I. B. Henning of the duPont Co.; Mr. H. H. Murray of the Victor Talking Machine Co., and others.

Professional Notes

WATERVLIET ARSENAL

Step Threading of Breech Blocks and Breech Bushings.

The step threading of breech blocks and breech bushings of the "Welin" type presents an interesting machining proposition which requires the use of special attachments to the standard machine tools which are not ordinarily met in commercial manufacture.

The methods and attachments which are in use at Watervliet Arsenal in performing the above operations on breech blocks and bushings for the 16-inch Mk. III mechanisms are as follows:

The breech block is first finished-bored, faced, threaded for carrier hub and turned cylindrical to within .01-inch of the radii of the largest sectors. The sectors are then laid out by means of an outline template on the end which locates the sectors in proper relation with the carrier hub thread.

The breech block is next set up on a slotter and slotted to form, leaving approximately .01-inch on each sector to be removed with the threading tool. All the side walls and tool clearance cuts between sectors are, however, finished to drawing dimensions.

Upon completion of the slotting operations the breech block is placed in the step threading machine which consists of a standard 48-inch screw cutting engine lathe equipped with a special arbor for holding the breech block during the threading operation. (See Fig. 1.)

The arbor has a cast iron base to hold the breech block away from the face plate to permit sufficient flexibility in the step threading mechanism which is operated from a large gear which is an integral part of the cone driving pulley.

The arbor and base are securely bolted to the face plate and fitted with a nut on the tail stock end to permit the block, which is a sliding fit on the arbor, being securely fastened to it. The block is prevented from rotating by a stop pin in the cast iron base of the arbor, coming in contact with one of the sectors of the block.

The step threading device (Fig. 1) for the block consists mainly of a cast iron housing with a dovetail on the bottom side parallel to the axis of the lathe and by which it is assembled in place of the compound rest slide, the compound rest being set so as to permit longitudinal adjustment by means of the compound rest screw.

A cam shaft carrying a cam for generating the step thread passes through the housing at right angles to the tool block slide which is rectangular in shape and is free to slide in the housing. The front of the tool block slide carries the cutting tool while the center portion is slotted out to permit insertion of cam and cam shaft. A hardened tripping stud is inserted in the tool block slide at the front end of the cam recess and against which the cam operates. In the lower portion of the housing are two spring recesses into which are assembled the tool block slide retracting springs. A plate is attached to the rear of the tool block slide which carries the spring rods against which the retracting springs operate and in turn retract and keep the tool block slide in contact with the cam.

The motion is imparted to the cam shaft by a series of gears and shafting connecting with the large gear on the cone pulley of the lathe and transmitted through a shaft fitted with two universal joints which permits the traverse movement of the cross slide.

To prevent damage to fixture or work or possible breaking a gearing due to malfunctioning or other causes, a shearing pin is inserted in the driving shaft and the driving belt on the lathe is reduced in width and left loose enough

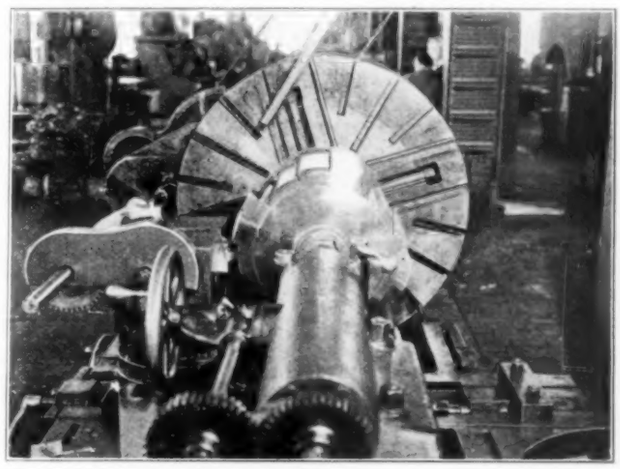


Fig. 1. Step-threading a Breech Block at Watervliet Arsenal

to permit slipping should the load be suddenly increased. The back gears are also set so that any unusual load will throw them out of mesh.

When the breech block has been assembled in the lathe, the proper location of the thread is determined by means of a thread locating template by applying same to the proper center line on the block. The root location of several threads is prick-punched on the sector where the template is applied and the point of the cutting tool roughly set thereto by means of the compound rest feed screw in the housing. As the threading proceeds, final adjustment is made to conform with the locating template. The cam action is properly adjusted by slipping out of mesh one of the pinions on the driving shaft and reassembling at the nearest gear tooth. Final adjustment is made by means of a dog and adjusting screw connection in the driving shaft. This adjustment must be made very accurately as the tool clearance between adjacent sectors is very limited.

In the threading operation the thread is generated in the usual way by means of the lead screw, the function of the step threading device being merely to retract and advance the tool for threading the sectors of different height.

Three sets of tools, two high speed roughing and one

carbon finishing tool, are used in the threading operation; the first is a solid tool ground to the proper angle of the thread with a radius corresponding to that at the root on the point; the second is similar in form except that it is ground to the full profile of the thread and also forms the radius on the top of the thread. This tool is used only when the thread has been roughed out to a point which requires forming of the top radius. The third or finishing tool is a spring, or gooseneck tool, ground to the full profile of the thread and is used for final finishing only.

The threading of the breech bushing is accomplished in a similar manner except that the bushing is screwed into a chuck attached to the face plate of the lathe.

The threading attachment is however somewhat different in construction in that the housing attached to the compound rest slide is fitted with an extension or arm which carries the tool block slide and cam in the forward end. The motion is imparted thereto through gearing and a shaft passing through the extension or arm.

Due to the limited space in the head of the arm which carries the cam, the retracting springs cannot be made sufficiently long to properly retract the tool block slide in all positions. To overcome this difficulty, an eccentric collar is mounted on the cam shaft to equalize the tension on the springs for the various steps on the cam. The machining operations are performed in the same manner as those pertaining to the breech block.

Removing Liner from 14-inch Gun

In removing the liner from 14-inch Gun, No. 18, Model 1910, MI, a variation from the past method was employed. It will be recalled that the 14-inch guns, model 1910 and 1910, MI are built by shrinking the liner and the B tube together, first, and then wire wrapping the B tube. The hoops are then assembled. This results in a high compression between the liner (A tube) and B tube. In fact, this compression is so great that it is not practicable to heat the gun to a temperature high enough when it comes back for relining, to separate these surfaces. This is due to the fact that the walls of the liner are too thick to respond quickly to the quenching, and gripping takes place between the walls of the liner and the B tube. Considerable data have been accumulated as to the effect of temperature on the square cold worked wire used in the manufacture of guns at Watervliet Arsenal. So great is the danger of destroying the effect of the wire wrapping by excessive heat, that a limit of 400° F. (including shop temperature) has been set as a maximum temperature to which the gun may be heated in any of its stages of manufacture. Excessive heating of this wire while under tension produces a permanent set which in turn releases a certain amount of the tension.

As stated above, the heavy compression that exists between the liner and B tube and the thickness of the liner walls were the reasons that the gun could not be relined by heating it as a whole and then quenching the liner, thereby breaking the contact between the A and B tubes and dropping the liner out. It so developed that this obstruction to the use of the old method of relining proved to be a means for employing a new method. By the application of standard gun formulæ, it was found that with the existing pressure between the A and B tubes, that the A tube had to be of a certain thickness or else it would be permanently compressed or over stressed. The original thickness of this tube was sufficient by far to prevent it from being over compressed. It can be readily seen then, that so long as the old liner had to come out and would be of no particular value in future construction, that the thickness of the walls might be cut down to such a dimension that the remaining shell would be greatly over stressed and a permanent set produced. This very fact of producing this set naturally produces a new outside diameter for the liner which is less (by the amount of permanent set) than the original outside diameter.

Due to the fact that the liner is assembled to the B tube with a taper of approximately .005 per inch, the metal removed from the liner had to be taken out in successive steps. Calculations show that if the liner wall were reduced to a thickness of about ¼-inch, the pressure exerted by the B tube wire and outer hoops would over-stress considerably this thin shell. This being the case, it is evident that by applying the old method of heating the gun and liner and then quenching the liner, separation between the liner and B tube would follow and the liner would drop out. In performing this operation the prescribed temperature of 400° F. was not exceeded. The gun and liner were set in the furnace, muzzle end down. They were then heated to the required temperature and allowed to "soak" for a certain time. By the circulation of water in the liner and at the same time lifting the gun by means of a plug screwed in the breech end of the liner, separation followed in three minutes.

A little side-light on the operation might be of interest at this point. The liner has one shoulder 117 inches from the breech end. In roughing out the metal from the bore of the liner, the thickness of the walls of the remaining shell was not uniform; in other words, the outer circumference and the inner circumference of the liner shell were not concentric. This variation in the thickness of the walls caused the shell to collapse. Up to the time the gun was "up ended" in the furnace, this collapse had not taken place. It is assumed then that this collapse took place after the cold circulating water hit this thin section. The liner had expanded very slowly due to the heat applied, but due to its thin section, its cooling or contracting took place much more rapidly. It is probable that the liner gave way slightly due to the forces causing contraction, and once it became distorted, its strength for resisting further collapse was so reduced that it resulted in a section about 3½ feet long being depressed 6 inches. One end of this depression was checked by the extra ring of metal necessarily left at the liner shoulder, the other end extended from this point 3½ feet towards the breech end.

The time taken in dropping out the liner was longer than usual. It is assumed that probably at the muzzle end, the shrink was not broken as soon as anticipated. In a recent issue of Army Ordnance (Vol. III, No. 19, July-August, 1923), the condition of the liner in this gun on receipt from the Proving Ground was described. It was noted that the bore was badly worn from the muzzle end back to the trunnions, the wear being greatest at the muzzle end and disappearing under the trunnions. This fact may have caused a slight change in the compression between the liner and the B tube at the muzzle end. It is quite probable that the muzzle end of the liner shell left in the gun was thick enough to resist the effort contemplated to over-stress it. It is intended to correct this point in the next relining by boring the liner shell thinner at the muzzle end so that the shrink will be broken there first.

A point on which no definite information has been secured to date is this, How does a body that has been subjected to permanent set behave under the influence of heat? Is the coefficient of expansion for "live" metal and over-stressed metal the same? There is a possibility that an investigation of this point might lead to some very useful data, especially in relining work.

The above method employed in relining gun No. 18 was

carried out entirely in one furnace. Heretofore it has been the practice to remove the gun and liner after heating to an adjacent quench pit where the liner was dropped out. This time the muzzle end of the liner which was at the bottom of the furnace, was plugged and a 2-inch outlet pipe lead over to the sump in the quench pit. The breech end of the liner was provided with a lifting eye and also four inlet pipes and four over-flow pipes. This provided for a circulation of cool water during the unshrinking. When the temperature had reached 400° F. and the soaking period past, the gun and liner were lifted about 6 inches off its seat in the furnace. This meant that in addition to the forces exerted by the quenching of the liner, an additional force equal to the weight of the gun acting downward was employed. This 6-inch drop of the gun when separation took place was not sufficient to damage the furnace in any way. There was considerable saving in time and naturally in heat by doing the whole unshrinking process in one furnace. A similar gun was relined at Watervliet Arsenal some time ago. The old liner was bored out entirely. This process was rather slow work as it required careful machining to avoid cutting through into the B tube and also not to run into the shoulder on the B tube. The liner in gun No. 18 was removed in considerably less than one-half the time it took to remove the liner in the other gun mentioned above.

A more interesting problem is yet to be solved in connection with gun No. 18. How can a new liner be assembled and produce the same strength in the relined gun as it had originally? As stated above, 400° F. is considered a safe temperature for heating the ⅛-inch square cold worked wire used at Watervliet Arsenal in gun construction. With this temperature together with a minimum amount of clearance required for "dropping in" a new liner, it will not be possible to get the same amount of compression and naturally the same amount of tension on the wire as when it was built. It is also believed that heating the gun (and wire) to 400° F. and holding the temperature there for any length of time relieves some of the strain due to winding a square wire on a cylinder. If this is the case, a permanent elongation has then taken place in the wire. Under these conditions it will not be possible to make a relined gun as strong as it was originally, even with the same amount of shrinkage. It might be well to consider the use, for future manufacture, of a heat treated wire of rectangular cross section. It has already been suggested that if a heat treated wire of rectangular cross section were used in which a "draw" temperature of 100° F. above the contemplated manufacturing temperature was specified, that relining guns would be more satisfactory. This would also lead to a construction having very slight contact pressure between the A and B tubes which naturally produces a condition approaching the ideal—that of a replaceable liner in the field.

FRANKFORD ARSENAL

Airplane Instrument

The instrument shown in Fig. 2 is for use in an airplane for locating a target in reference to a battery or reference point. It consists principally of the telescope (1), recording mechanism (2), the ball (3), and socket (4).

The telescope is of the prismatic erecting type at the lower end of which is attached the housing (5) containing the collective lens, reflecting prisms, objectives, reflecting mirrors, and windows. One surface of the collective lens is wedge-shaped for the purpose of halving the field, the ridge acting as a halving line.

The tilting of the reflecting mirrors is controlled by the knobs (6) and (7) through a system of gearing and worms attached to the lower ends of the shafts (8) and (9). Each reflecting mirror is capable of 35 degrees of rotation, which causes the rotation of a beam or ray of light of 70 degrees, totaling an angle of 140 degrees for both mirrors, which is the maximum vertical angle that can be measured. The upper ends of the shafts are fitted with gears, which form part of the gear train driving the revolution counter (10) through a system of

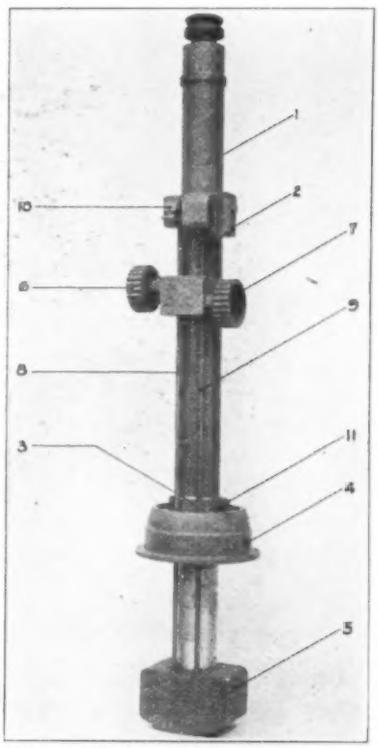


Fig. 2. Airplane Instrument, Model E

differential gearing, by which method the summation of the two angles is obtained.

A level is mounted on the wire holder, underneath the wire in such a manner that the bubble is in focus for the purpose of roughly indicating when the telescope is in approximately the vertical position.

The following are the optical characteristics: Power—2. Field of view—20 degrees. Exit pupil diameter—.3 inch. Clear aperture of objective, diameter—.6 inch.

The ball (3) and the sockekt (4) provide the flexible joint necessary to permit the observer to train the instrument on the target and battery or reference point. The ball is provided with a split collar and clamping screws (11) for locating at the desired position on the telescope tube, to adjust the position of the eyepiece to accommodate the observer.

The socket (4) is provided with a flange for attaching to the framing of the fuselage in the floor of the observer's cockpit, in such a manner as to protrude vertically between his legs and with the eyepiece in a convenient position, the lower end protruding through the floor and fuselage to obtain an unobstructed view.

Sight Mounting, Type T

Figure 3 is for use on the experimental model of the 75-mm. pack Howitzer carriage type B.

It consists principally of two separate units: The Panoramic Sight, type A, and the sight mounting.

The Panoramic Sight, type A, is of the usual type, miniature in size, with the following optical characteristics: Power, 3; field of view, 13.3 degrees; exit pupil diameter, .15-inch.

The eye-piece is rotatable, laterally, through an angle of approximately 180 degrees, a feature essential to prevent the gunner's head from obscuring the line of sight, when viewing an aiming point to the rear.

The sight mounting consists principally of the elevation,

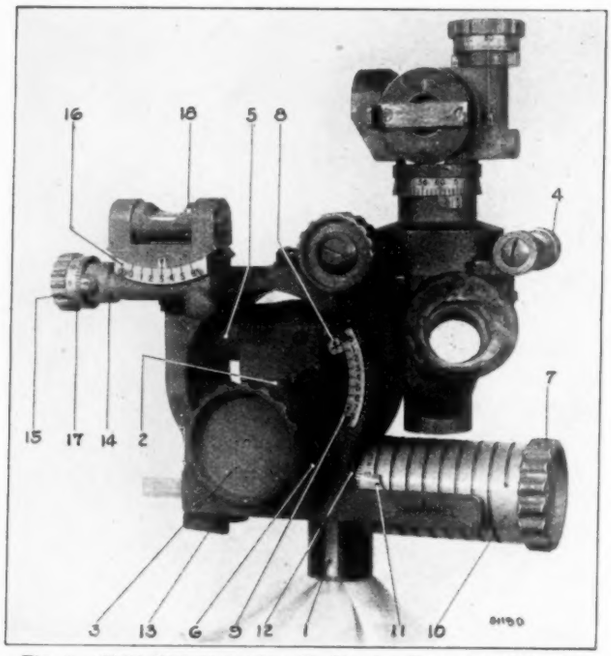


Fig. 3. Sight Mounting, Type T, Showing Panoramic Telescope in Position with Eyepiece Rotated Approximately 80 Degrees

crossleveling and angle of site mechanism. It is attached to the carriage by means of the bracket (1) the upper end of which carries the crossleveling worm segment (2) and the bearing for the pin forming the fulcrum about which the mounting rotates when crossleveling. The knob (3) controls this movement and the cross level (4) is provided for indicating when level.

The cross-leveling worm is enclosed within the housing (5) which is provided with bearings for the fulcrum pin. Its outer diameter forms a bearing for the body (6) and contains a worm segment which engages the elevation worm housed within the body and controlled by the knob (7). The index (8) is attached to the housing (5) and registers against the elevation scale (9) attached to the body (6), graduated in hundreds of mils.

The range drum (10) contains a spiral groove, which engages a pin attached to the pointer (11) causing same to move along the face of the drum when rotated, indicating range. The inner edge contains graduations indicating opposite the index (12) and serves as a micrometer, indicating single mils, when used in conjunction with the scale (9). The wing nut (13) operates a clamping device to prevent the rotation of the elevating worm during firing. The angle of site mechanism (14) is controlled by the knob (15). The angle of site scale (16) is graduated into hundreds of mil divisions. The micrometer (17) indicates single mils. The levels (4 and 18) are provided with covers to prevent injury to the vials. An extension is provided for raising the line of sight above the top of the wheels.

ROCK ISLAND ARSENAL

4.7-inch Gun Carriage, Model 1921 E

An interesting problem was encountered in the proof firing of the 4.7-inch Gun Carriage, Model 1921 E, at Rock Island Arsenal. The recuperator was tested in the shop in the usual manner by retracting the piece and permitting it to counter-recoil. Excellent results were obtained in this shop test. The piece had a maximum speed of counter-recoil of between three and four feet per second, and was retarded properly during the last inch of its return to battery position.

When the first round was fired, the mechanism functioned properly except that it slammed into battery without proper retardation at the end of the counter-recoil. The curve showed a maximum speed of counter-recoil of approximately five feet per second, which is to be expected, as the speed of counter-recoil when firing is usually somewhat greater than during a shop test. The regulator of the recuperator was then dismantled and examined, and no cause of malfunctioning could be observed.

The mechanism was then reassembled and another shop test made, which gave results similar to the previous test.

The piece was again proof fired and seemed to function satisfactorily in counter-recoil, although the last two inches of the counter-recoil ribbon were lost. Another shot was then fired and the piece slammed into battery, repeating the action noted during the firing of the first round. The piece was then brought into the shop and tested, and it functioned properly in counter-recoil.

It was noted that, whereas the piece was at zero elevation at the proving ground, during shop tests it was at a slight elevation in order that it might be retracted by means of a steel cable through a pulley from the traveling crane. Arrangements were then made which permitted the piece to be retracted in the shop with an elevation of less than one degree. A counter-recoil ribbon was taken with the piece in this position and it was found that the retardation during the last inch or so of counter-recoil had been materially lessened.

From this it was concluded that at the proving ground, with the piece at zero elevation and with the recoiling parts under the greater impulse as given by firing, the recoiling parts raced ahead of the floating piston into battery position. Proof firing was continued with the piece at zero elevation and using the respirator to prevent the piece from slamming into battery. This characteristic of counter-recoil has been noted in other designs. The piece cannot be fired at elevation at Rock Island Arsenal, as firings must be made into a butt.

Overhauling Airplane Motors

Some time ago Rock Island Arsenal contracted to overhaul, for the Air Service, U. S. Army, 400 Liberty 12-A motors taken from storage. This overhaul included tearing the motor down and thoroughly cleaning all parts, careful checking and inspection of all parts of the motor and the substitution of certain modified parts, reassembly of the motor, test run and preparation for shipment. It was also necessary to put the engine in first-class running condition and to pass an acceptance test outlined by the Air Service.

The engines when received had the crankcase and cylinders, together with the manifolds and all other openings, containing a considerable amount of oil and grease. The outside of the motors had been sprayed or slushed with a heavy coat of protective grease. In order to remove this oil and grease expeditiously, it was necessary to build a steam oven. This oven was of a box construction made of

2-foot by 4-inch superstructure, on which was nailed corrugated sheet iron, both on the inside and outside. The hollow space between the two walls was filled with fine, dry cinders. The inside of the oven was made large enough to accommodate two engines and was lined on both sides and ends with steam radiators. Two stands were built inside the oven in such a manner as to permit the engines to stand on a slightly inclined plane. The oven was further provided with two heavy insulated lids hinged in back and counterbalanced for opening and closing. This oven was placed in the main craneway of the shop and its design permitted the use of cranes for lowering engines into the oven and removing them therefrom.

The motors were received in especially prepared boxes from which they were removed, picked up by crane and lowered into the oven. They were allowed to remain in the steam oven from one to two hours, depending on the amount and the condition of the grease and oil. During this time, twenty pounds of steam was carried in the steam radiator. The grease and oil flowed from the outer surfaces of the engine on to a sheet metal plate previously placed beneath the engine stand. It in turn drained into a large steel pan, thereby preventing any grease from reaching the floor. This pan was handled by the crane also. At the proper time, the motors were lifted out and placed on a revolving assembly stand. The drain plugs and covers of the crankcase were removed and the hot oil allowed to drain out into a large steel pan. The cover plates over the exhaust ports, the spark plugs, and all other cover plates were removed at this time. The engine was then turned upside down and allowed to completely drain. At the same time, the crankcase was wiped as clean as possible on the outside. The engine was then turned back to the upright position and all exposed parts wiped clean of grease.

The engine was next passed to the disassemblers who disassembled and stencilled the various parts to assure assembling these various pieces back into the same motor. Such assemblies as the water pump, carburetor, camshaft housing with camshaft, etc., were given a cleaning with a mixture of kerosene, gasoline and air-sprayed, and then removed to previously prepared departments where they were further disassembled, cleaned, inspected and modified, where necessary. They were then reassembled and again inspected and held in readiness to be transferred to the General Assembling Department.

During this time, cylinders were removed from the crankcase and passed to the cleaning stand where they were cleaned with kerosene, gasoline and air-sprayed, and were then removed to the valve grinding department where valves and springs were removed. The valves and cylinders were then thoroughly cleaned and inspected, particular attention being given to inspection of cylinders for leaky water jacket, trueness of bore and condition of valve seats and valve stem guides. The valves were inspected for pits, cracks, warping and overall length, and necessary corrections made, if possible. The valves were given a light machine grind of the valve seat and of the end of the stem to bring the valve to proper length, after which the valves were ground in their seats in the cylinders. The cylinders, with valves assembled, were then tested and inspected and the cylinders removed to the paint department where they were painted, allowed to dry and removed to the General Assembling Department.

The pistons were removed from the connecting rods and the piston rings removed from their grooves, tied together and tagged. Pistons were washed in kerosene and sent to the machine shop where they were modified by turning a slight groove and drilling several small holes through the piston, connecting the grooves with the inner side of the piston and thus allowing surplus oil to drain back into the crankcase. This modification was expected to reduce the oil pump tendency of the engine. The modified pistons were returned to the wash rack and thoroughly cleaned, the piston rings reassembled and the complete assembly inspected and returned to the General Assembling Room.

Meanwhile, the crankcase was being disassembled, except for the bearing dowels, drain tube assemblies, oil tube, bearing bolts and studs. Certain modifications were then made in the crankcase such as cutting keyway for the lower ball bearing container and drilling a 1-7/16-inch inspection hole in one end of the crankcase, relocation of the original name plate and drilling and tapping and assembling of a new inspection plate. At the same time, the propeller hub was removed from the crankshaft, which was then rough cleaned and tested for the alignment of bearings and otherwise inspected. The crankshaft was then straightened, if necessary, and the bearings polished. The propeller hub was lapped to a perfect fit and then thoroughly cleaned and reassembled. The main bearings and connecting rod bearings in the crankcase were burnished to mirror-like surfaces.

By this time, all necessary parts such as fuel pump, drive shaft assembly, water pump, oil pump, camshaft, gun control and distributor head, had been modified and new parts obtained, where necessary. All gears in the camshaft gear train were replaced by stub tooth gears and these parts were ready for reassembly in the engine.

The lower crankcase was placed on a rigid wooden stand and the lower main bearings and water pump bevel drive gear placed in position and made fast with the bolt provided. The crankshaft with gear thrust bearing and propeller hub in place was fitted to the lower crankcase and the backlash in the gears checked. The crankshaft was then transferred to the upper crankcase where the remaining gears and their respective assemblies were put in place and properly adjusted for clearance. The crankshaft was then transferred to an especially designed stand where the connecting rods were assembled to it. It was then transferred back to the upper crankcase and the lower half of the crankcase lifted into position and properly bolted in place. The oil pump and water pump were then assembled to the crankcase. The crankcase assembly was now transferred to the General Assembling Room where the remainder of the motor was assembled in place.

For convenience in assembling the pistons to the connecting rods, an electric oven was used. The pistons were heated just sufficiently to expand the piston pin hole to a point where the pin was an easy slip fit. It was then immediately assembled to the connecting rod. The cylinders, with a slight film of oil, were slipped over the pistons and lightly bolted in place. The cylinders were then tapped into alignment within a tolerance of .0015 and the nuts tightened. The intake headers were found to be badly sprung and it was necessary to lap them on a large cast-iron surface plate before assembly to the engine. After lapping, however, a neat and tight job was obtained without setting up any appreciable strains. All water connections were then made and the carburetors were hung in position, having been previously conditioned in a separate department, as before mentioned. The gun controls were then fitted to the camshaft housing and the entire camshaft assembly, assembled into position on the two banks of cylinders. The timing and setting of the tappets was then done and the engine turned over to a crew who assembled in place the high tension cables, breaker mech-

anism and distributor heads. The ignition system was then synchronized in a conventional manner employing battery and small electric lights. The spark plugs were placed in the cylinder heads, and terminals attached. A general inspection of the complete motor was then made and motor shipped to the testing laboratory where it was mounted on test stand.

The test consisted of a preliminary warming-up of one hour's duration. A full throttle run of thirty minutes duration and an idling test of ten minutes duration. The test club used was a propeller so constructed that it would absorb 410 h.p. at 1,700 r.p.m under standard atmospheric conditions. Gasoline was fed to the carburetor by air pressure of two and one-half to three pounds. Readings of r.p.m., water temperature, oil pressure and air pressure were taken at intervals of ten minutes throughout the run and check made of the gasoline and oil consumption. Following the full throttle run, during which time the engine must develop a speed of 1,700 r.p.m., the engine was given a ten minutes idling test to detect over-oiling in any of the cylinders. At the end of the acceptance test, the compression in each cylinder was again tested by turning the cylinder over by hand. The engine was then removed from the test stand and transferred to the shop where it was again carefully checked for valve clearance, valve timing, oil and water leaks, synchronization or breakers and ignition timing.

The motor was then carefully drained of oil and water and otherwise cleaned, including crankcase, oil screens and spark plugs, and prepared for storage.

WATERTOWN ARSENAL

Standardization of Gun Carriage Parts

About a year ago, the Chief of Ordnance decided to establish various design sections at the several arsenals. Prior to this time practically all designs were prepared in the Office of the Chief of Ordnance by the Railway and Seacoast Carriage Section, Mobile Carriage Section, Cannon Section, Tank, Tractor, Trailer and Motor Carriage Section, or the various other sections of the Department. A nucleus from the personnel of the various sections of the Department was transferred to the Watertown Arsenal for railway and seacoast carriage work, to the Watervliet Arsenal for cannon work, to the Rock Island Arsenal for mobile carriage tank, tractor, trailer and motor carriage work, to the Frankford Arsenal for sights, fire control, ammunition, etc., and to Springfield Armory for small arms.

When the designing was done in the various sections of the Office of the Chief of Ordnance, it was difficult to prevent duplication of designs of practically the same parts used in the different sections, but with these design sections at the various arsenals, it is much more so. For this reason, recently the Ordnance Office directed the standardization of dimensions of parts, to eliminate as far as possible special ordnance standards and to utilize those recommended by the A. E. S. C., S. A. E., A. S. M. E., etc.

All lathes, drills, planers, shapers, slotters and other machinery were analyzed, and after the speed and feed question had been definitely settled, slots of all face plates on lathes, slots on planer platens or other machines were standardized with the view of providing interchangeability. All tee bolts and other means of fastening were likewise standardized, so that when the machinists require means for fastening their work to the various machines, these can be obtained from the Tool Room.

A chart was prepared for each machine on which is shown the diagrams of the driving and feed mechanism, together with the amount of speed and feed of the various speed and feed combinations. When the machines were mechanically driven, a great many changes of pulleys and gears were necessitated in order to obtain the proper geometric ratio of the speed combination, as well as the proper ratio for the various points in the feed. In the case of motor driven machinery it was necessary to calibrate the resistance in order to obtain the proper ratio of speed increments.

The belt drives were standardized by determining the limitation of the tightness of the belts to avoid unnecessary slipping and obtain the maximum driving power for the particular belt and thereby the maximum output of the machine.

Standard cutting tools for all kinds of work and all kinds of machines were also introduced as well as the regrouping of similar machines. The standardization of the tool room has also been introduced by the procurement of specific means for the storage of tools, measuring instruments and other appliances.

From diagrams and data obtained in standardizing and calibrating there was found, even in machine tools of comparatively old designs, the greatest advantage in connection with equalizing the output of different machines when work of the same character is assigned to them.

Prior to the calibration of the machine tools at this arsenal the production by two men doing the same kind of work on the same size machines, supposedly of equal construction, and using the same instruction card differed by 30 to 40 per cent, the more capable man often giving the smaller production. By exchanging the men, the better mechanic usually failed to increase the production of the machine first operated by the less capable man. After the machine tools had been calibrated very exact results would be obtained by the same two men on the same job. The cost of thus rehabilitating, calibrating and standardizing the machinery, by reducing the subsequent cost of production in a short time more than paid for the improvements made.

Standards adopted by the Ordnance Department are valuable in direct proportion to their use by commercial industry. In case national standards of the type required in ordnance construction are not available, industrial manufacturers' standards should be ascertained, and used in the preparation of ordnance standards, in order to utilize, if possible, the standards of industrial corporations who perform a similar grade of work.

This standardization of parts when adopted does not affect old manufacture, but is used in connection with new design work, and for that purpose the standardization of parts has been divided between the arsenals and a program prepared in order that proper coordination may be secured between the different arsenals where standardization work is being undertaken, thereby eliminating duplication of work.

The Watertown Arsenal has already studied and completed standardization of commercial wrenches, both double head and single head; cable straps; cable terminals; hydraulic pipe fittings; clutches, single end and double end; handwheel handles; clutch rollers, and clutch roller screws; and is preparing to take up handwheels, lamps and sockets, oil plugs, packings, gaskets, grease cups, oil pipe connections and fittings, terminal tubes, tools and accessories, etc.

The Rock Island Arsenal has standardized brake rod ends, brake rod end pins, eye rod ends, adjustable yoke rod ends, serrated shaft fittings—taper type, taper fittings with nuts and lock washers, ball and socket joints, ball studs, lock washers, square fittings for permanent fits, grease cups, 4, 6, 10 and 16 spline fittings, table of stand-

ard allowances and tolerances for automotive parts, and table of tap drills sizes for the national coarse and national fine threads.

The parts thus standardized or data collected are prepared on sheets in accordance with current drafting room practice and are arranged in a manner similar to those published in the S. A. E. handbook.

It is expected, with the accomplishment of standardization of ordnance material, and with the use of the new system of classification and preparation of ordnance office drawings recently adopted, to eliminate duplication in designs in the Ordnance Department. The introduction of these new standards with the new method of detailing parts, will materially reduce the cost and time of preparation of designs. It will also reduce the cost of production and permit commercial firms to produce immediately, in case of emergency, in large quantities, material which has been commercialized rather than having to first prepare special tools, fixtures, jigs and machines, etc., for parts made of special designs. In addition to this standardization, the department is endeavoring to simplify the construction of gun carriage parts to be cast, especially in steel, by eliminating intricacies in design. Steel castings in the past have caused considerable criticism and delay in production; but in the case of another war, private concerns will be able to quickly prepare patterns and provide good castings by having simple designs to cast.

In the preparation of standards of electrical fittings endeavor has been made to follow strictly commercial practice and the standards recommended to the department are those used by electrical manufacturers.

In the case of railway and seacoast gun carriages, it is somewhat difficult to follow commercial standards, as many parts are special to the design and standards of these do not exist; also there is not the same advantage in the commercialization of ordnance standards for the products of the Watertown Arsenal as, for instance, there is for those of the Rock Island Arsenal, the war production problems being entirely different for these two arsenals.

The department, however, can afford to simplify its practice for seacoast and railway material by standardizing its own peculiar designs, whereas in the case of mobile and tractor material the department insists upon commercializing its standards as well as simplifying them. However, knowledge of standardization work being carried on by manufacturers of similar products will be obtained and followed wherever possible.

In carrying out this work, the department has decided to disregard the work which had been done in the past on seacoast material and prepare standards for new design work only, assuming that carriages now in emplacements at the fortifications of old design would not be reproduced in case additional ordnance projects are required.

Standardization of Machine Tools and Accessories

In a well equipped and organized manufacturing establishment where machine tools of all kinds, and necessary accessories pertaining to these tools, constitute the equipment of the establishment, it might be expected that the machines had been so constructed and calibrated that the increments of speeds and feeds would be in a geometric ratio and also the capacities of the machines; that is, the principal dimensions which will affect the size and kind of work that can be assigned to any specific machine, should be known.

The inconsistencies in design of many machines have been plainly demonstrated at the Watertown Arsenal with respect to the characteristics referred to above, and it is necessary therefore in connection with the introduction of a new system of shop management to prepare diagrams of every machine tool showing the speeds and feeds and the driving arrangement in order to determine the changes which are necessary in order to obtain certain fixed ratios of speeds and feeds as well as to list the capacities for work of each of these machines.

GENERAL

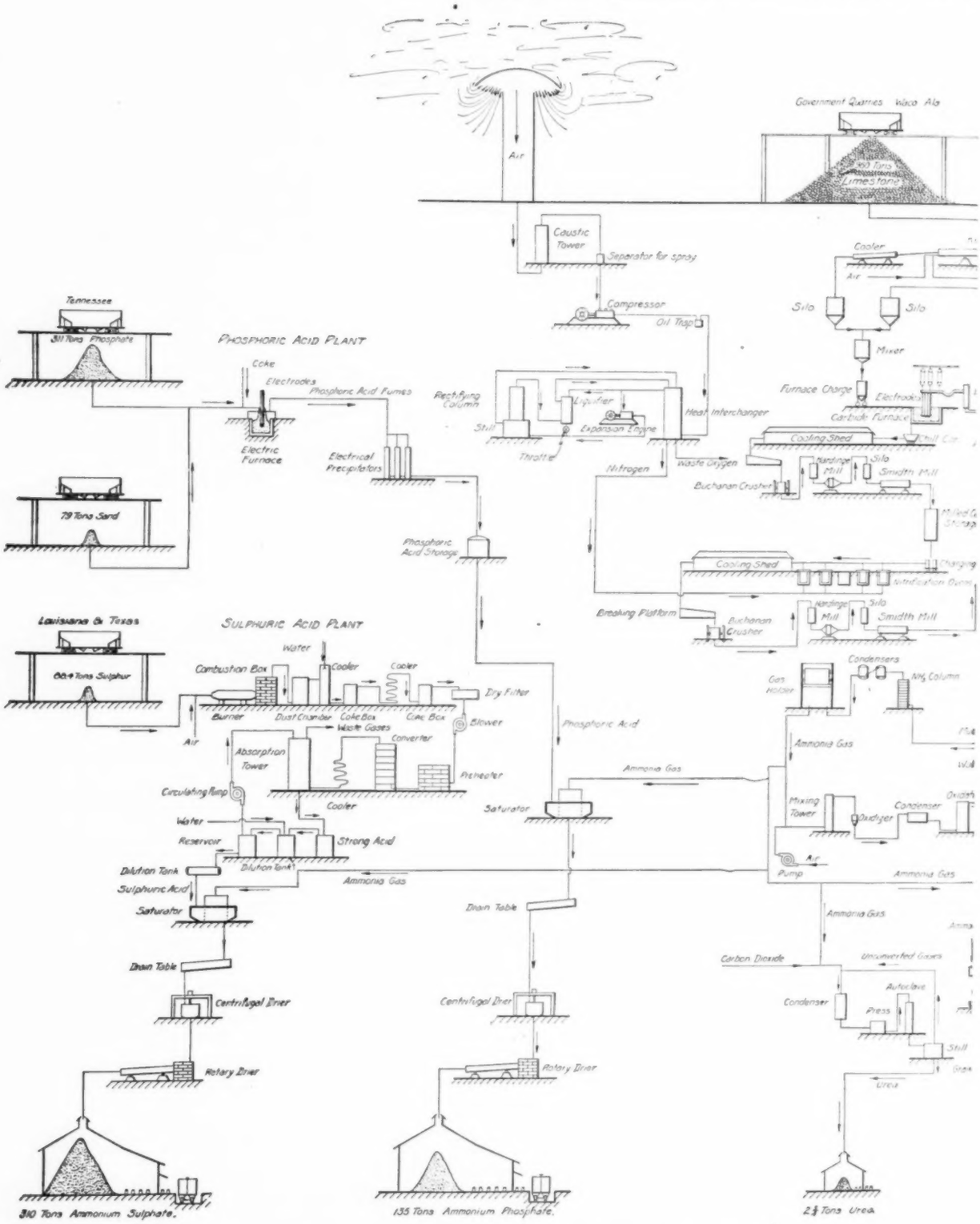
A New Muscle Shoals Development

Until recently very little constructive criticism has been forthcoming regarding the proposal of Henry Ford to purchase Muscle Shoals and proceed with the utilization of that vast war-time property. A welcome change in that situation is H. R. Bill 3222, introduced in the House of Representatives by Mr. Dickinson of Iowa. This bill in effect is a challenge to any who are genuinely interested in the production of cheap nitrates and in the utilization of such water power as may be developed by Dam No. 2. Space does not permit an actual comparison between the original Ford offer and this bill, but a few salient features will be emphasized.

First of all, the bill authorizes a lease and not the outright sale of the property, it being believed that the objects to be achieved are as easily attained under a lease as under sale. Any complications as to purchase price and other details are thus eliminated. This lease would be for fifty years, and is therefore in conformity with the Federal Water Power Act. In fact, the whole question is treated in the same manner as would be done were a license issued under the Federal Water Power Act and, in addition, a definite subsidy for fertilizer production is being offered. Mr. Ford would be relieved of the initial payment of $5,000,000. The Government itself would complete Dam No. 2 and the interest on the Government investment in the dam and power units, the maintenance, and depreciation thereon would be met by a payment by Mr. Ford of 6 per cent per annum of the actual cost of acquiring the lands and flowage rights and of constructing the dam, power house, and power house facilities, but not including the cost of locks or other navigation facilities which are entirely removed from this transaction.

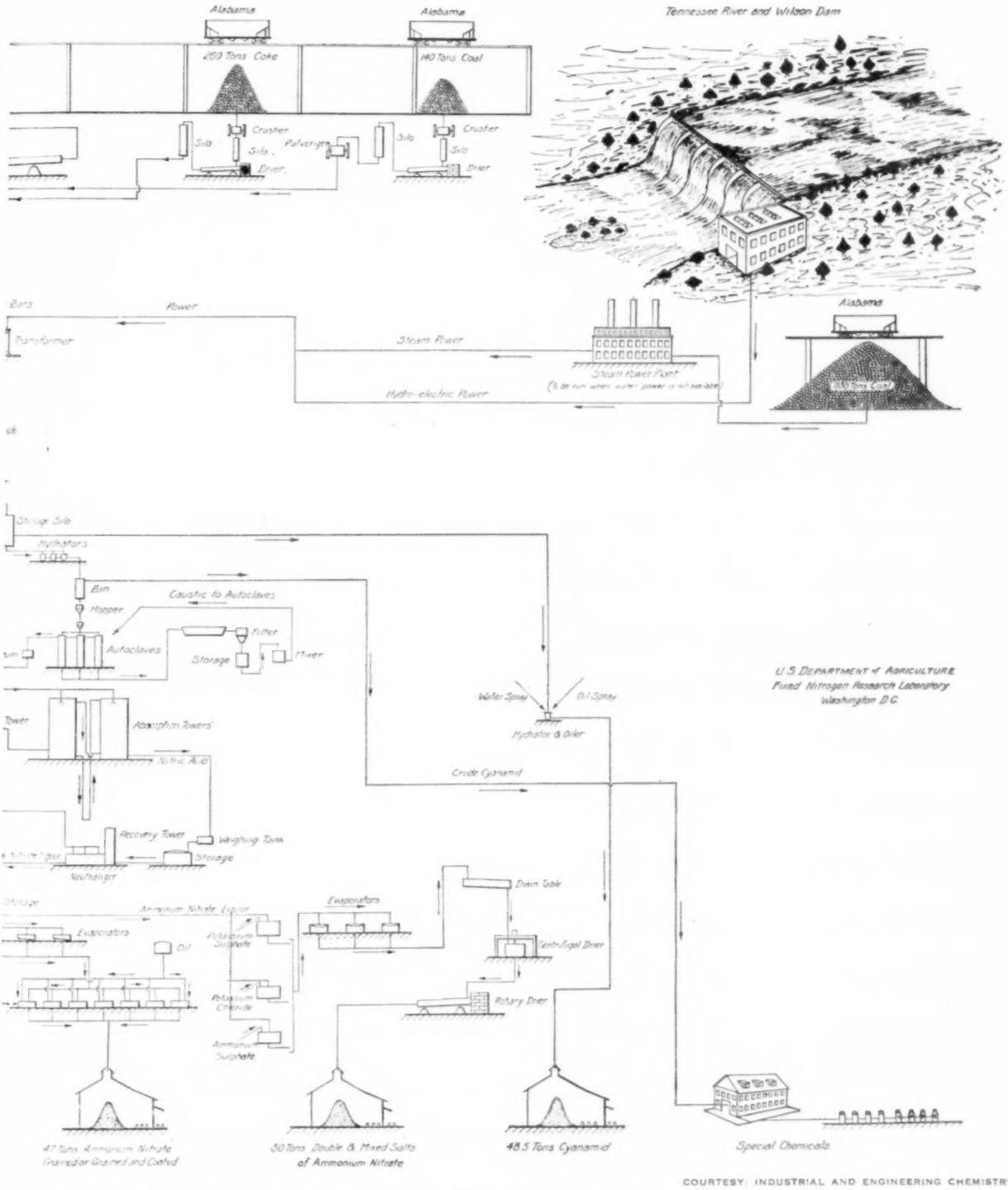
The subsidy for the production of cheaper fertilizers is to be found in the provision that the interest rate shall be reduced from 6 to 3 per cent in direct proportion to the power used for nitrogen fixation by whatever process the company may elect. In other words, if half the power is used for this purpose, then the interest on half the invested sum would be not 6 but 3 per cent. The company to be organized by Mr. Ford is to make all necessary renewals and repairs incident to efficient maintenance of the power house, etc., at its own expense, and Nitrate Plant No. 2 or its equivalent is to be maintained in its present state of readiness for immediate operation for the manufacture of materials necessary for the production of explosives in the time of war. This provision seems to conform to the wishes of the War Department that such facilities be maintained in a stand-by condition. As in the original Ford offer, the bill provides that at least 40,000 tons of fixed nitrogen shall be the annual output and that the company is entitled to make not more than 8 per cent on the fair actual cost of production during each year, this cost to be determined by a board empowered to regulate the price at which the fertilizer may be sold so that the net annual profit shall not exceed 8 per cent. The board would consist of seven appointed from among the nominations

Possible Agricultural Utilization of U. S.



This chart represents a distribution that could be achieved in a few years rather than distribution possible on the basis of the present fertilizer market. It indicates a possible step in a progressive scheme. For example, a market for ammonium phosphate, ammonium nitrate, the double and mixed salts of ammonium nitrate, urea, etc., would have to be established, and thus it might develop that the distribution here suggested is not necessarily the best, or indeed a possible one.

Nitrate Plant No. 2, Muscle Shoals, Ala.



COURTESY INDUSTRIAL AND ENGINEERING CHEMISTRY

It is believed that ammonium phosphate should gradually and progressively displace ammonium sulfate as a product of the plant.

The figures indicated for daily tonnages of various products are equally tentative. The Fixed Nitrogen Research Laboratory in cooperation with the Bureau of Plant Industry has conducted extensive agricultural experiments on all the fertilizer materials indicated on the chart. Figures show daily tonnage.—*(From: Industrial and Engineering Chemistry, January, 1924.)*

of the American Farm Bureau Federation, the National Grange, and the Farmers' Educational and Cooperative Union, with two voting members selected by the company. Further, the company would agree to manufac ture nitrogen and other commercial fertilizers continuously throughout the lease, unless prevented by causes beyond its control.

This bill also proposes, as did the original offer, to have determined "by research whether by means of electric furnace methods and industrial chemistry there may be produced on a commercial scale fertilizers of a higher grade and at lower prices than farmers and other users of commercial fertilizers have in the past been able to obtain, and to determine whether in a broad way the application of electricity and industrial chemistry may accomplish for the agricultural interests of the country what they have economically accomplished for other industries, and if so found and determined, to reasonably employ such improved methods."

The bill provides for proper compensation to the company for investments in new properties or for additions to or betterments of existing properties constructed or made at its own expense and used or useful in the manufacture of nitrogen should the lease not be renewed or the property later disposed of to another under conditions no less favorable to the Government. While it gives the company the right to use all the patents, processes, methods, and designs which have been acquired by the United States with reference to Plant No. 1, it also gives the United States the right to use any and all patented processes which the Government may need in the event that the several plants are operated by the Government in time of war.

As regards the power to be used for processes other than the fixation of nitrogen, the company would be treated as is any other company leasing power under the Federal Water Power Act. * * *—*From Industrial and Engineering Chemistry—January, 1924.*

The Malfunctioning of Ammunition

(Continued from page 226)

springs, also, remaining for so long under tension, have lost their strength, causing duds in the same way.

Bombs

Prematures, using the strict meaning of the term, do not occur with bombs, as there are no sudden initial forces exerted on the bomb such as are exerted on a shell when it is being propelled from a gun; likewise bomb fuzes being armed by the rotation of a propeller as the bomb rushes downwards are incapable of premature functioning. Premature explosion of a bomb may occur if it is not fuzed correctly or if it is meddled with by the uninformed. The most serious accident occurring with a bomb was the result of an unexpected succession of unusual occurrences. A bomb accidentally dropped from the rack of an aeroplane as the latter was taking off, the safety wire pulling out as the bomb dropped; the wind from the propeller of the plane spun out the propeller of the bomb fuze thus arming it; the skid of the plane as it moved forward struck the fuze driving in the firing pin, the bomb as a result giving a high order detonation with disastrous results. That such an accident might happen was almost beyond the bounds of imagination. The fuze, however, has since been so modified as to eliminate even this remote possibility of trouble.

Duds and low orders with bombs are produced generally by the same defects as in the case of artillery ammunition, faulty loading and deterioration of explosive causing most of the duds obtained with bombs dropped on land. Duds were common with the 17-lb. fragmentation bomb due to the lead-covered TNT fuze leading from detonator to booster becoming insensitive. By replacing the detonators with an improved type, and by replacing the fuze with tetryl pellets completely filling the extrusion, these failures have been eliminated.

Perhaps the most difficult problem which demands solution is to obtain dependable functioning of bombs on water impact. Too many duds are still obtained when bombs are dropped on water, these failures appearing to the greatest extent with delay primer detonators in tail fuzes. In the latter, fuze functioning is brought about by the retardation of the bomb on striking water allowing the firing pin with its weight to overcome the resistance of a spring and pierce the primer. The retardation, however, on water impact does not appear to be sufficient to cause the primer to function to a degree necessary with delay primer where a delay pellet is interposed between primer and detonator, even when the spring holding the firing pin from the primer has been reduced considerably in strength. Experiments are still being carried out to find a solution to this problem. The particular difficulty in this work is that the bombs have to be dropped from high altitudes on deep water, making recovery and examination of duds impossible. As, however, bombs using primer detonators are usually equipped with nose and tail fuzes, the percentage of duds obtained with bombs thus doubly fuzed is not large.

Pyrotechnics

The malfunctioning of pyrotechnics generally takes the form of failures, which may be called duds. Pyrotechnics, like other forms of fireworks, have their burning compositions composed of mixtures of chemicals which readily deteriorate. Parachutes, also, when kept within the close confines of the signal or flare for a long time, do not open readily, often allowing the burning pyrotechnic composition to fall quickly to the ground, thus failing to give the necessary illumination and often setting fire to dry grass. Much better types of pyrotechnics have, however, been developed since the Armistice, and the adoption of these new types together with manufacture of only such quantities as can be used within a reasonable time will practically eliminate failures. The Mark I airplane flare has been renovated in large quantities by the replacement of the primers and black powder expelling charges, the packing of these components in waterproof containers, and the overhauling of parachutes.

Recovery of Ammunition Duds

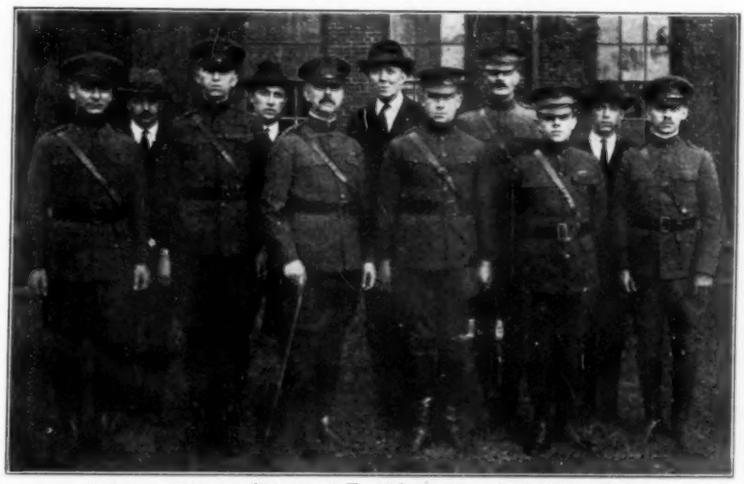
It has been said that the word "dud" was suggested by a certain provincial pronunciation of the word "dead." A dud, however, although apparently dead, may have the power to leap into sudden disastrous life when "recovery" is attempted. Those responsible for the development and production of ammunition desire to obtain reports as to the manner in which ammunition functions in actual use, as it is largely by means of the information thus gained that the defects in ammunition produced in quantity are revealed. The examination of duds, however, is a hazardous occupation and should be left to experts.

Reserve Corps Notes

Reserve Officers Training Course at Frankford

The training course for Ordnance Reserve Officers held at Frankford Arsenal, Philadelphia, Pa., November 12 to 24, accomplished excellent results. The course was attended by ten reserve officers and covered instruction in methods of procurement, manufacture and inspection of small arms and other ordnance matériel manufactured at the arsenal.

Those who attended the course were: Captains E. S. Arford and Henry B. Reardon, Jr.; First Lieutenants, John O. Brennan, John Cetrule, Edward M. Floreyk, L. A. Haskett, and Douglas L. Rehlaender; and Second Lieutenants Walter I. Ettleman, Rosewell Jinkins, and Alonzo B. Woodruff.



Ordnance Reserve Officers at Frankford Arsenal Training Course

Left to right: (Front row) First Lieutenant John Cetrule; Second Lieutenant Walter I. Ettleman; Colonel Odus C. Horney, Commanding Officer, Frankford Arsenal; Captain Henry B. Reardon, Jr.; First Lieutenant Edward M. Florcyk; and First Lieutenant Douglas L. Rehlaender. (Second row) Second Lieutenant Alonzo B. Woodruff; First Lieutenant John O. Brennan; Captain E. S. Arford; First Lieutenant L. A. Haskett; and Second Lieutenant Rosewell Jinkins.

It should be an inspiration to all reserve officers to know that these men, who were willing to give their time and effort to a period of study of their duties in time of war, were most enthusiastic about the course. The instruction, which was given under the direction of Colonel Odus C. Horney, Commanding Officer at Frankford, and his staff of able assistants, covered the most important phases of ordnance functional activities. The men were instructed in the essentials of design, procurement, manufacture and inspection of small arms and small arms ammunition. Frankford Arsenal is the main manufacturing plant of the Ordnance Department for small arms and optical instruments. The course also included study of artillery ammunition, including shells, fuzes, and cartridge cases, as well as the various kinds and types of optical instruments.

Judging from the reports received from those who attended the course, there seems to be no doubt that whatever personal sacrifice attendance at the course may have meant to the officers, they were well repaid for their efforts. It is to be hoped that conditions will warrant a growing interest and attendance for such courses in the future.

Correction

In the November-December, 1923, issue of ARMY ORDNANCE, the name of the law firm of which Brigadier General John Ross Delafield, of New York City, is head, was erroneously given as Delafield, Powell, Thorne and Rogers. The correct name of the firm is Delafield, Thorne and Burleigh. ARMY ORDNANCE regrets the error.

New Ordnance Reserve Officers

The following have accepted commissions in the Ordnance Officers' Reserve Corps since the last issue of ARMY ORDNANCE:

Colonel James C. Heckman and Lieut. Cols. Herbert A. Gidney and Paul L. Pierce.

Majors William R. Baldwin, Arthur E. Bellis, Thomas J. Buckley, Rupen Eksergian, Alexander K. Hamilton, Reuben Hill, Alexander L. Jenkins, Francis A. Pattison, Charles H. Rhodes, Harold C. Strohm, Rudolph F. Whitelag, and Otis K. Wright.

Captains Eugene P. Armstrong, Byron W. Benedict, Robert B. Cable, Jr., Don P. Carpenter, Russell H. Drukenbrod, Franklin R. Hoadley, William P. Hutchinson, George W. Jones, Fred Mandler, Henry N. Marsh, George R. Metcalf, Stephen K. Plume, Clinton G. Reed, Martin L. Thompson, and William M. Wood. 1st Lieuts. Stanley G. Cady, William J. McGinnis, Victor Muller, Benjamin R. Newcomb, Roland W. Sellew, Arnold J. Stevens, Marion A. Tharp, James E. Van Toor, and Clarence F. Woodford.

2nd Lieuts. Norman D. Baker, Harold A. Bull, Walter C. Cummings, Willard J. Foster, Lawrence H. Franchot, William E. Ghent, Amos W. Huyett, George B. Kutz, Willard G. Malsie, and Kirtland Marsh.

Reappointments in Reserve Corps

The five-year period of appointment is expiring for a large number of reserve officers and the following have accepted reappointment in the Ordnance Officers' Reserve Corps:

Major Edson R. Dorman, Capts. Percy C. Avery, Arthur E. Jewell, Ellis R. Northrop, and Carl A. Wendell.

1st Lieuts. Herbert L. Allwood, Walter C. Berger, William F. Butler, Charles J. Brethauer, Lambert D. Fowler, Alvin J. Kohn, Delmar L. McGovney, Anton Mill, Jr., and John W. Surburg, Jr.

2nd Lieuts. Ross A. Abell, Neal E. Allen, Garfield Appleyard, James E. Arkell, Roy L. Baber, Richard M. Balmert, Herbert W. Barlow, Frederick M. Barnicoat, Arthur P. Barringer, Merlin G. Batley, Elias C. Baum, Bryan Baumgardner, Martin B. Bechtel, Jacob Bennett, Reno V. Berquist, Don C. Billick, Harold C. Black, John K. Black, Weldon J. Black, Charles A. Bleilevens, John A. Blount, Jr., Rascoe Bond, George L. Bowman, Martin S. Bowne, Noah O. Bradley, Lawrence W. Breck, Frederick L. Britton, Donald C. Brown, Oscar C. Bruce, Edwin M. Buchanan, Clayon O. Butler, Russell R. Byer, Perry M. Chadwick, Joseph Chebuske, Carl L. Cleeland, David Clyman, Lester M. Collins, Francis S. Dare, Charles H. Dobson, Jr., Ernest C. Dudley, Cyrus C. Dulaney, George F. Elliott, Vern G. Engelman, Alva E. Erwin, George W. Evans, Wylie B. Ewing, Linton S. Fergusson, Guy R. Freeman, Claude W. Frey, Ernest J. Fridrich, Edward R. Frizzell, William M. Fuqua, William H. Furey, Milton Gevurtz, Joseph N. Glaser, James M. Gordon, Stanley M. Gordon, George R. Gray, Cecil R. Gregory, Frederick C. Griffin, Roland S. Grubb, Charles J. Guthier, Leonard A. Hammes, Silas C. Hansen, James R. Haptonstall, Albert F. Harris, Leroy Hedges, Eugene D. Henley, John W. Hennessy, Carl H. Henrichson, Harrison E. Howe, Cary A. Hudson, Robert M. Husband, Walter C. Jetton, Walter B. Jones, Kenneth P. Kahlke, Harold O. Keedy, Norman L. Keller, Alvin C. Klotz, Freeman L. Knight, Herbert G. Kraft, George F. Langford, Mayer S. Levin, Alden W. McCormick, Howard C. McCrady, Robert D. McDonald, Thomas F. McKee, Eugene F. McQuesten, Ralph H. Millam, Charles W. Millen, John K. Miller, George H. Mills, George M. Montgomery, Phil D. Morelock, James P. Morgan, Forest W. Murphy, William B. Murphy, Harry B. Nelson, Parker C. Nelson, Claude I. Newell, Lou K. Newfield, Hollis W. Newton, Gordon F. Nielsen, Robert A. Norton, William E. Norton, Lewis R. O'Daniell, William M. O'Donnell, Preston E. Osborn, Donald H. Painter, Paul V. Pallasch, Ralph H. Park, Edwin H. Parker, Ralph C. Parmenter, Frederick S. Parsons, Ross T. Phipps, Richard A. Picard, Arthur G. Porcher, Charles D. Proctor, Claude F. Quackenbush, Robert H. Ratcliff, Howard D. Rice, Lesley C. Robertson, William H. Rosenfeld, Lloyd R. Rohtermel, Preston O. Rudy, Jr., James D. Ryan, Esmond Schapiro, Earl E. Scott, Joseph L. Scott, Ralph C. Scott, Edward T. Shadek, Howard C. Sherman, George B. Shivery, Clarence A. Shook, Frederick W. Shopp, Herbert H. Sichel, Harold M. Silver, John S. Simmons, Michael T. Simmons, Park E. Sleister, Carl P. Smith, Samuel D. Smith, Russell M. Srout, Sherman P. Storer, Randall E. Stover, John J. Sullivan, Harvey E. Taylor, Robert H. Thieman, Arthur H. Thompson, Norbert R. Thornton, Thomas H. Tighe, Jr., Henry M. Toole, Roy C. Troeger, George R. Tuttle, Robert B. Vaughan, Benjamin A. Vrieling, Raymond R. Waln, James W. Warner, Robert W. Warner, Albert E. Warren, William E. Warrington, Edwin J. Watson, Harry N. Weinberg, George Weiss, Julian H. Weissbein, Oliver F. Wheatley, Joseph H. Whitehead, Riley H. Whitman, Frederick A. Wiecking, Luke J. Wilburn, Russell H. Wilgus, Price W. Williams, Hilliard H. Wimpee, Jr., Howard P. Wiitten, Stewart B. Worstall, Park L. Yorke, L. C. Zimmerman, Vern A. Zimmerman.

Colonel Wagner's Course on Basic Chemicals

The Ordnance Office, through the voluntary assistance of Lieut. Col. Fred H. Wagner, The Lombardy Apartments, Guilford, Baltimore, Md., is preparing a number of articles on the procurement of basic chemicals for explosives to be distributed to reserve officers with chemical experience. Each article will be in two parts.

Colonel Wagner, being a chemical engineer of national note, is excellently prepared to write these courses, as he served during the war as a Major of Ordnance and was promoted to the grade of Lieutenant Colonel October 5, 1918. He served in the Nitrate Division and as Director of Operations of htat Division from August, 1918, to November, 1919. From June to August, 1919, Colonel Wagner was in Paris as a member of the Nitrogen Commission. He has spent the past 30 years in the design, construction and operation of chemical plants. At present Col. Wagner is consulting engineer for The Bartlett Hayward Compnay, of Baltimore.

The Ordnance Financial Cycle

(Continued from page 248)

conclusively used to pay, upon proper vouchers, obligations lawfully payable under the respective appropriations.

All purchases of ordnance, ordnance stores, or supplies, and the procurement of services not personal, are made by contract either after advertising and proper award, or in open market. Advertisement is a necessary preliminary to all purchases of material or services not personal, except in such cases as—

(*a*) Emergency, when the public interest demands immediate delivery of the articles or performance of the services;

(*b*) When it is impracticable to secure competition;

(*c*) When the aggregate value of the material or services does not exceed $500.00;

(*d*) When the character of the article required or the ingredients thereof are of such a nature that the interest of the public service would be injured by divulging them publicly; or,

(*e*) When the service is for newspaper advertising. Newspaper advertisement, however, is prohibited except under special or general written authority of the Secretary of War.

The Cycle

To sum up, the financial cycle from the inception of estimates to the final disposition of the paid account by the Comptroller General, and return of the unexpired balances to the Treasury, is somewhat as follows:

(*a*) Submit estimates to Congress for funds;

(*b*) When appropriated, funds are recorded in Treasury, and are subject to requisition;

(*c*) They are then apportioned and allocated to the various purposes for which made;

(*d*) They are then sub-apportioned or allotted for various specific purposes which become actual obligations, and on which payments are based;

(*e*) Payments by disbursing officers;

(*f*) Submission of money papers for audit;

(*g*) Audit by General Accounting Office;

(*h*) Cover into Treasury unused balances after appropriation expires by limitation.

Book Reviews

The World Crisis—1915. By Rt. Hon. Winston Spencer Churchill, First Lord of the British Admiralty, 1911 to 1915. Charles Scribner's Sons, New York. xiii., 578 pages. Price, $6.00.

Mr. Churchill is peculiarly well qualified to write on the military and naval operations of the Allies during 1915. For several years prior he had been First Lord of the Admiralty and had been largely responsible for the readiness and strategic location of the British Fleet in 1914. He was a member of the British War Council and thus was familiar with all the Allied operations. While not technically educated for naval service he had always been a student of strategy and tactics. Mr. Churchill is a man of great ability, wide experience, keen vision, and abundant enthusiasm and energy. First in his position as First Lord of the Admiralty and later as Minister of Munitions, he contributed largely to England's share in the Allied success.

The author realized late in 1914 that the war on the Western Front was becoming stabilized, with a battle line resting one flank on Switzerland and the other flank on the North Sea. In his opinion no decision could be reached on this front for months and he believed correct strategy required that turning or flank movements should be attempted. All the operations initiated and so actively supported by him in his position as First Lord of the Admiralty were efforts to turn the enemy flanks and to separate his forces. As he says: "Are there not other alternatives than sending our armies to chew barbed wire in Flanders? Further, cannot the power of the Navy be brought more directly to bear upon the enemy?" These questions were always in his mind and he was constantly attempting to use the superior British Naval force in a decisive manner, first in the North Sea and later in the Dardanelles.

A very considerable portion of the book is devoted to the Dardanelles operations, the conception of the idea, the difficulties of its initiation, his struggles against opposition in British official circles, and a detailed description of the operations during the period he was an active participant and later, after he left the admiralty, when he was a mere observer.

His conceptions were usually brilliant, but, due to pressing needs in other theaters of the war, he was not able to deliver a blow heavy enough to win. He was intolerant of delay and his boundless enthusiasm and lack of technical training caused him to force the issue before proper preparation and coordination had been effected.

A very interesting feature of the book is the story of the association of Mr. Churchill, as First Lord of the Admiralty, with Lord Fisher, as First Sea Lord of the Admiralty. While the two did not always agree, both being men of very positive ideas, their friendship and mutual forbearance held them together for quite a long period. The Dardanelles, however, wrecked their association, Mr. Churchill favoring it and forcing the issue and Lord Fisher opposing and always advising against the continuation of the Dardanelles naval operations.

The book is in no sense an apology by Mr. Churchill, but is a detailed account of his side in many controversial subjects. It is a book that any military student will find worth while.

Questions of the Hour. By Viscount Milner. Published by George H. Doran Company, New York. 5 Essays, 173 pages. Price, $4.00.

England's foremost Imperialist, Viscount Milner, in his latest book, "Questions of the Hour" has sought to analyze in five masterly essays pressing questions confronting the British government of today. The questions treated by the author are mainly economic but woven here and there throughout may be seen threads of faith in the ultimate political destiny of the Empire when vexing and threatening aspects of the present economic situation are finally eased and cleared away.

Particular attention is devoted to the relations of Capital and Labor, and to the growing power of the latter in the State. Some rather novel expedients are suggested for the reconciliation of views and more effective cooperation of these two great factors in the economic life of the nation. Two essays are devoted to this important subject and a clear line of constructive suggestion for the solution of a problem apparently insoluble is sustained throughout both. The novelty of one suggestion in particular is worthy of remark—"Instead of Capital hiring Labor, Labor should hire Capital." This premise, which the author insists is neither novel nor revolutionary, is then developed along the lines that large scale production and the personal responsibility and pride of the individual worker in his task, which was characteristic of the old-time independent craftsman, are not incompatible. Further, this ideal object may be attained by association of the workers for large scale production using their own capital or by borrowing the use of capital from those who have it.

Taxation and the mania for government economy are treated in another essay. Sources for taxation furnish a rather interesting subject for suggestion after indirect and direct taxation, outright confiscation of wealth, and government ownership of revenue-producing public utilities have been dismissed as inadequate. "Would it not be possible for the State to become, so to speak, a sleeping partner in industry, leaving the initiative and management, under reasonable control, to private enterprise, but reserving to itself a share in any surplus profit after the active partners, Labour and Capital, had received an adequate reward?"

The book as a whole furnishes food for thought. The author is to be praised for his bold protest against what he considers more or less illogical solution of some of England's pressing economic problems. However, "through the mist of current controversy" he has tempered the protest constructively in every instance by groping his way "to some firm resting ground of principle."

From Immigrant to Inventor. By Michael Pupin. Published by Charles Scribner's Sons, New York, 1923. Price, $4.00.

This is an intensely interesting narrative of the life and adventures of one of our leading physicists, Michael Pupin. It reads like a romance and should appeal to young and old alike. The struggles and sacrifices of the peasant boy, the young immigrant, the Columbia student, and the search for knowledge in English and German universities, show that steadfastness and courage are required at every step through life.

Parts of the book form are interesting commentary on the politics and customs of the old world which the author links and compares with those of the new. Interesting and intimate glimpses of famous scientists of Europe, notably Tyndall and Helmholtz, are shown. Through it all, in a most skillful manner, is maintained the motive that kept the boy, the student, and the scientist, moving toward success—in search of the answer to the question, "What is light?"

The author's narration of the discovery of the practical application of induction coils to long telephone lines contains a moral worthy of reflection.

This is a book that might well be read by every American youth.

The Americanism of Theodore Roosevelt—Selections from His Writings and Speeches—Compiled by Hermann Hagedorn. Published by Houghton Mifflin Company, Boston, Mass. 317 pages. Price, $2.50.

"Americanism" is a much misused and abused term of vague meaning to the average American. It is therefore interesting to read a book in which this trait of character is attributed to Theodore Roosevelt, and to note the development of the thesis by an orderly succession of extracts from the historical, social, and political writings of the man himself.

The book itself is intended to serve a double purpose—"to provide a selection of the striking passages from Theodore Roosevelt's writings, and to serve as an interpretation of his mental processes, of his moral, social, and political philosophy, and of the life in which that philosophy expressed itself." The editor has achieved his purpose by providing first a background from Mr. Roosevelt's historical writings in which the basis for the social and political philosophy of the man is laid in fundamental conceptions of the heroic virtues. The pioneer days of the United States form the subject for the development of this background.

The transition from the background to the Rooseveltian political and social philosophy is simple. The pioneer virtues established in the background may be likened to the base of a pyramid. The apex is the brotherhood of man. The pyramid is built up as follows:

"I. The elemental virtues—the basis of good citizenship.

"II. Good citizenship—the basis of just government.

"III. Just government—the basis of national unity.

"IV. National unity—the basis of national strength.

"V. National strength—the basis of international peace."

The application to the private and public life of the man of the doctrines established in his philosophy of life forms the subject for the third sub-division of the book. Did he practice what he preached? The extracts would seem to be well selected for this purpose. His political opponents might, however, be captious enough to insist that the extracts have been too well selected, and to point out instances where a difference of opinion on the practice of a noble philosophy might arise.

We were interested in learning whether the interesting riddle "Americanism" is expounded in a few words anywhere in the extracts composing this book. The following from "American Ideals" seems to be the answer:

"Americanism is a question of spirit, conviction, and purpose, not of creed or birthplace."

As a last thought it may be said that Mr. Hagedorn, in compiling this much needed tonic philosophy, has effectively pointed the way through a mist of post-war confusion to the base of the Rooseveltian pyramid—the elemental virtues which form the basis of good citizenship.

Where Are We Going? By the Rt. Hon. David Lloyd George, British Prime Minister, 1916-1922. Published by George H. Doran Company, New York, 1923. 31 chapters, 371 pages. Price, $3.00 net.

In this work the "little Welshman" has presented a running comment on the European situation for the past year in the epigrammatic style of a liberal thinker. All of the wealth of a varied and stormy Parliamentary experience has been thrown into the preparation of this series of articles. The picture painted of European conditions is not a rosy panorama of peace and quiet. The tares of war are being sown assiduously by nations already forgetful of the message of peace on earth carried in the Versailles Treaty. "You have all the elements which made for the great war of 1914 more potent than ever today. The atmosphere of Europe is charged with them."

France in her more or less futile efforts to collect reparations by forceful occupation of the Ruhr is arraigned severely as a prime mover in a distinct retrograde movement which is lighting the fuze for another general explosion of national hatreds. The author does not hold a brief for an easing off of practical penalties for Germany's crime against mankind but believes that simple justice should prescribe just and possible conditions.

For Americans it is interesting to note that the author emphasizes again and again the importance of the New Haven speech of Mr. Hughes in which the Secretary of State suggests a tribunal of impartial financial experts to determine the sum total of reparations and Germany's capacity to pay.

The chapters of the book are really separate articles in each of which a special phase of the tangled European situation is discussed. For the reader who desires a clear and interesting account of foreign conditions from the pen of a keen analyst of present day events, this book may be recommended.

Diplomatic Portraits: Europe and the Monroe Doctrine One Hundred Years Ago. By W. P. Cresson. Published by Houghton Mifflin Company, Boston. 571 pages. Price, $4.00.

There comes a time in the experience of the reviewer of books when enthusiasm conquers the critical sense and unalloyed satisfaction must be acknowledged. For us, "Diplomatic Portraits" brings on such a period. In substance, it is a striking presentation of historical data concerning our one and only international doctrine, its genesis, its sponsor, and the people who—wittingly or unwittingly—were instrumental in its foundation.

Most of us will remember from our studies of American history how the great Monroe Doctrine was pronounced by the President whose name it bears, on the second of December, 1823. Most of us have some idea

of the causes which brought it about. All of us, no doubt, are firm believers in it and staunch defenders of it in all its import. But how many in this day and generation are acquainted with the activities that went on behind the scenes in those critical times? And today when popular interest in our foreign policy has succeeded in pushing the old common places from head lines of the press and "Monroe Doctrine" is preached vociferously from the housetops and applauded by all, how many realize the close analogy between those days and the present? Might it not be well for us in an effort to really understand this one great and only international dogma of ours to study and know the personalities and events that actually gave it birth.

Dr. Cresson's book is a superb historical narrative—told with a delicacy of style and ease of expression that make it a worthy companion-piece. We have seen no better or more interesting treatment of the great author of the Monroe Doctrine, nor of the various personages whose activities influenced the pronouncement of that doctrine. The book contains fascinating accounts of Alexander I of Russia, Napoleon, Castlereagh, Tallyrand, Marie de Krudener, John Quincy Adams, Gentz, Metternich, Chateaubriand, and Monroe. Each "portrait" is as fine a thing as we have come across in a long time. Historically, "Diplomatic Portraits" is an epoch-making book; as an addition to one's library that can be read and reread with profit we know of none better.

Applied Business Finance, 2nd Edition. By E. E. Lincoln. A. W. Shaw Co., New York; xviii plus 772 pages. Price, $4.00.

This book presents a discussion of business principles and practices from the standpoint of the *average* industrial manufacturing or trading concern. While the problems confronting the larger organizations are more spectacular, after all the public interest is bound up in the smaller concerns to a much greater extent—there are many more of them and they are much less likely to have the advantage of expert guidance and wide experience. From this point of view, as well as from its general excellence, the book is to be welcomed as a real addition to the literature of business. Its author has been a member of the staff of the Harvard Graduate School of Business Administration and is now Chief Statistician of the Western Electric Company.

Starting with a general discussion of business finance and the business cycle, the author goes on to a discussion of the average industrial concern and the basic question—"Shall the enterprise be launched?" He treats of the various forms of organization, means of raising capital, the business and investment banker, the stock market, ownership, financial statements, purchasing, producing, selling, the results of size, credit, earnings, etc. In short, the present book is a comprehensive study of the whole of the financial aspect of business and will be of great service to business men and others interested in the subject.

Source Book of Research Data. Prepared by the New York University Bureau of Business Research. Prentice-Hall, Inc., New York, 1923. xi plus 70 pages. Price, $4.00.

As indicated by the title and authorship, this is a source book of *business* and *commercial* statistics. The object of the book is to give a list of sources of current statistical data covering the most important commodities and a few other items such as telephones and buildings. The list is divided into two parts, one giving sources of quantity statistics (production, shipments, stocks, etc.), the other giving sources of price statistics.

No attempt has been made to make the book all inclusive, either as to commodities or as to sources of statistical information concerning the commodities listed. The endeavor has been to give a representative list of *reliable* source of data covering the most important commodities. In general, when the same information is given by two sources of equal reliability and merit, as for instance, "Bradstreet's" and "Dun's", but one of he sources is listed. This is for the sake of preventing unnecessary duplication.

"The Source Book of Statistical Data" will be of great value to business men, bankers and others who have need to look up commercial statistical data. New York University and the publishers have rendered a distinct service to the commercial world in making the information available at the present time.

Commerce Year Book, 1922. Compiled under the direction of the Bureau of Foreign and Domestic Commerce, the United States Department of Commerce. Can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. 692 pages. Price, 60 cents.

The publication abounds in statistical information pertaining to production, prices, imports and exports of all major industries for the year 1922 and the early part of 1923 compared with similar information for previous years. The data is presented in a concise and usable manner and appears very thorough in its compilation. Each general heading is well summarized in a short paragraph in bold faced type. A portion of the book is devoted to economic reviews and statistical data for all foreign countries.

The purpose in bringing forth a government publication of this nature is to assist in stabilizing business and industry and smoothing out the ups and downs of business cycles. It is thought that buyers of large quantities of supplies can, through its use, ascertain to a reasonable degree of accuracy the existing quantities of supplies available and, thereby, better avoid under-buying as well as over-buying. The result of this should be reflected in greater prosperity throughout the nation.

It is essentially a reference book and is of interest chiefly to industrialists, bankers, economists and those desiring to make academic studies of business and industry and the availability of resources.

The present publication is the first of its kind and will undoubtedly improve with the yearly revisions which it is planned to make. It is hoped that these future revisions can be published while the statistics are more up to date than is the case in this, the first issue. Unlike many government publications the book is printed on good quality of paper and bound in a stiff cloth cover.

Roger Bacon's Letters. By Tenney L. Davis, Ph.D., Assistant Professor of Organic Chemistry, Massachusetts Institute of Technology. Chemical Publishing Company, Easton, Pa. 1923. 73 pages.

This little volume is mainly a translation from the Latin of Roger Bacon's letter, written in 1252, entitled "Concerning the Marvelous Power of Art and Concerning the Nullity of Magic," which is of special interest in that it is assumed to contain Bacon's directions for the manufacture of gunpowder, concealed by means of a cipher. This portion of the letter has been discussed by Professor Davis in "Roger Bacon's Gunpowder," ARMY

ORDNANCE, Vol. III, pp. 280-3 (Mar.-Apr., 1923). Other portions of the letter demonstrate that Bacon possessed a very modern idea of the therapeutic value of autosuggestion, that he was familiar with such mechanical devices as the pulley, with lenses and burning glasses, etc. He even refers to the possibility of submarine boats, self-propelled cars, flying machines, and suspension bridges.

The translation is preceded by an interesting discussion of "Roger Bacon's Life and Works," and is followed by a collection of explanatory notes which add greatly to the interest of the volume, as well as support the author's version of the cipher.

This little book will appeal particularly to those interested in explosives, but, in the words of the author, "the general reader will find in it much which intrigues the interest and stimulates the imagination."

Charts and Graphs. By Karl G. Karsten. Prentice-Hall, Inc., New York. xl plus 724 pages. Price, $6.00.

This is an unusual book, both in the scope covered by its subject matter and in the method of treatment. The author attempts to provide a systematic treatise covering practically all the many means used in presenting data graphically. He covers both mathematical and non-mathematical charts, and in the former case shows how the formulæ and methods have been developed, illustrating his subject by a wealth of material drawn from a wide variety of sources. In the opinion of the reviewer, the task has been most excellently performed. Some of the subjects covered in the fifty-three chapters and six appendices are Maps and Diagrams, Route-Charts, Pie-Charts, Bar-Charts, Historical Curves, Cycles, Zee-Charts, Progress-Charts, Summary-Charts, Frequency Curves, Rate-of-Change Analysis, Rate-of-Change Scales, Rate-of-Change Curves, Logarithmic Frequency Curves, etc.

The author's style is philosophical and informal; it is remindful of the works of John Perry and Oliver Heaviside in its breezy character, but does not contain the lapses into sarcasm so frequent in these authors. A quotation will best illustrate this point:

"A word may be said as to the style of the text. It is a quaint and curious folk-way of the academic world that a technical account is worthy of respect directly in so far as it can *not* be understood. This hoary tradition is not limited to college walls—the rocky road to business, until recently, has rested on the self-same supposititious secrecy, and the paths of all professions lead to inner circles that guard, as best they can, the knowledge and the standards of their work. When such precautions make for better craftsmanship, they are most heartily to be endorsed. But, when they merely further selfish ends, they are a plague and pestilence, and those who practice them, only that their own minute monopolies of craft may be entrenched, come, sooner or later, into the class of parasites, retarding the growth of their profession.

"Having confessed so little patience with the doctrine of the incomprehensible *per se*, we have naturally sought to empty the entire bag of tricks, and to tell the whole story of the chart in the simplest words that we command. Our belief has been that it is a lesser sin to be too easily understood than never understood at all. But at the same time, we have sought to make the story full and complete. If any of our readers find charts which do not fall into place in this account, but would appear to have been omitted, we beg that they will freely advise and assist us to include them. It is, moreover, probable that, in spite of vigilant revision, many errors have crept in; we hope that readers who detect them will courteously co-operate by sending corrections, suggestions, and criticisms."

The reviewer is unable to agree with the statement in the footnote on page 8, that the changes in length of equivalent of horizontal distances between the top and bottom floors of very large buildings, due to the varying distance from the center of the earth may be as much as "several inches." As a matter of fact, in any existing building, it cannot be more than a small fraction of one inch.

American Coast Artillery Materiel. Prepared in the Office of the Chief of Ordnance. 513 pages, illustrations, bound in buckram. Ordnance Department Document No. 2042. For sale by the Superintendent of Documents, Washington. Price, $1.00.

This work is one of the finest that has ever appeared on the subject. It is complete, thorough and exact. It should prove to be a most valuable handbook for all those, military and civilian, who are interested in coast artillery matériel.

Part I of the volume contains a history of the development of artillery. Part II traces and explains the many steps connected with the design and manufacture of a great seacoast weapon. Part III gives a detailed description of American seacoast guns and mounts. Part IV is devoted to tables of miscellaneous data.

Much of the credit for this monumental piece of ordnance literature is due Colonel H. W. Miller, formerly of the Artillery Division, Office of the Chief of Ordnance, who is one of the foremost authorities on seacoast weapons in this country. His excellent articles on the "German Long Range Gun" which appeared in recent numbers of this magazine, will be recalled by our readers.

We, too, hope, with Colonel Miller, that this book "will serve the purpose of giving to the early as well as the advanced student such a comprehension of the problems of development, design and manufacture of seacoast artillery as will enable him to render more efficient service in any branch of the Army having to do with any type of artillery." We recommend this volume to everyone interested in the subject.

Catalytic Action. By K. George Falk, Harriman Research Laboratory, The Roosevelt Hospital, New York. Published by The Chemical Catalogue Company, Inc., New York, 1922. 172 pages. Price, $2.50.

A great deal of this work is devoted to an attempt to obtain an ideal definition for "catalysis," and in doing this much valuable data dealing with catalytic actions is given. The author's preference, however, in considering "a catalytic reaction as a reaction in which the chemical composition of one of the final products of the reaction is the same as that of one of the initial substances," while being more accurate, is—to all but the purely academic—less valuable than Ostwald's definition of a catalytic action as involving an increase in velocity by the presence of a substance which is unchanged after the reaction. There are very few rules and definitions of value which do not reveal exceptions in their application.

The chapters of "Enzyme Actions" and the "Chemical Interpretation of Life Processes" are particularly interesting. The author wisely leaves the reader to decide whether the "life process is created or begun continuously in and to form living matter" or "is not created at all—being the chance result of certain catalytic actions (later to be known as enzyme actions) on suitable material."

Recent Patents

Brief Descriptions of Inventions of Interest to Ordnance Engineers

Compiled by W. N. Roach, Chief, Patent Section, Office of the Chief of Ordnance

Implements of war appear to be susceptible of improvement as is evidenced by the number of patents being issued. A fair percentage of these patents is secured by foreigners, and of those issued to citizens of the United States it is pleasing to note that a large percentage have been issued to officers and employees of the Government.

Ammunition

Patents issued on ammunition are listed in the following order: fuses, projectiles, projectile loading, and explosives.

A fuse for use with drop bombs or shells is disclosed in patent to L. E. Remondy, No. 1,459,075. In this fuse the striker and primer are placed in a movable type of carriage, the forward element being affixed to the carriage with spring interposed between the elements. The carriage is held in forward position by a shear pin, the idea being that the members will function when the carriage strikes an obstacle in flight but the carriage and elements will move as a whole on a blow sufficient to shear the carriage during handling.

A larger form of lower striker is shown in the patent issued to R. Hass, assignor to Techno Service Corporation of New York, No. 1,462,173. This patent was issued under the Nolan Act.

A fuse provided with double safety locking means is shown in the patent to Major J. H. Woodberry, No. 1,462,313.

Another patent issued to Major Woodberry, No. 1,462,314, discloses a fuse provided with double firing means.

A fuse with a passage-way between the detonator and booster and a centrifugally movable plug normally closing the passage-way with a means for locking the plug in armed and unarmed position is shown in the patent to Roy L. Lowman, No. 1,463,747.

Patent to H. Jacob, assignor to the firm of Optische Anstalt C. P. Goerz Aktiengeselschaft, No. 1,466,834, shows a fuse for drop bombs in which the firing pin is locked in unarmed position by means of a centrifugally operated locking device.

A fuse from which the firing mechanism is released from unarmed to armed position by the flow of a liquid, the liquid flowing solely under the action of centrifugal force and the regulation being affected by varying the quantity of liquid which flows through a capillary orifice of constant cross-section, is disclosed in the patent to Eugene Schneider, assignor to Schneider et Cie, No. 1,472,941.

Patent No. 1,473,355, issued to E. R. Pillars and H. C. Leeseberg, discloses a minor caliber fuse distinguished principally for its simplicity in that no springs or centrifugal releasable locking members are used.

A new form of setting for the rotating band for a projectile is shown in patent No. 1,475,578, issued to Robert A. Hadfield and Alex G. McKenzie Jack, the purpose being to strengthen the shell at the forward end of the groove for the rotating band so that the base of the shell will not be fractured or broken off by whipping of the shell when striking armor plate at an angle.

A shell provided with hooked arms which fly out and extend radially during flight is disclosed in patent No. 1,460,043, issued to John C. Daynix. The object of the hooked arms is to catch in and damage an aeroplane or balloon.

Patent No. 1,459,198, issued to Leonid A. Dunajeff, discloses an attempt to produce a long range projectile by providing gliding surfaces on the projectile and also making provision for producing a vacuum above the projectile.

The modern example of the old ball and chain projectile is found in patent No. 1,464,192, issued to Russell A. Willson. The inventor has designed a projectile for use against aircraft.

In patent No. 1,470,591, issued to Manoel F. Behar, formerly lieutenant in the Ordnance Department, is an attempt to prevent errosion in a gun barrel by providing an angular pocket at the forward end of the cartridge case in which gas will be trapped and thus prevent its escape about the projectile as it unseats from the cartridge case.

Ernest Ludorf, assignor to the firm Pilum, A. G., in patent No. 1,468,822, discloses a projectile containing its propelling charge thereby doing away with the necessity for a cartridge case.

Patent No. 1,473,257, issued to Walter O. Snelling, assignor to Trojan Powder Company, covers the use of metallic resinates or rosin esters in place of rosin or cholophony in explosive mixtures to overcome the difficulty of caking when stored.

Patent No. 1,472,691, issued to W. O. Snelling, assignor to Trojan Powder Company, discloses an explosive consisting of nitro-starch and lead nitrate with which oil may also be mixed.

A primer composition containing trinitrophloroglucine is disclosed in patent No. 1,470,104, issued to Hans Rathburg. The advantages claimed for this composition are that it may be stored for any length of time even in hot or damp localities, that it is indifferent to metals in humid air, and that it has a greater gas pressure than fulminate of mercury.

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